PB81-164626

User's Guide to the Texas Climatological Model

Texas Air Control Board
Austin

Prepared for

Environmental Protection Agency
Washington, DC

Aug 80

U.S. Department of Commerce
National Technical Information Service
NTIS

PB81-164626

USERS' GUIDE

Texas
Climatological
Model

Texas Air Control Board

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. EPA/DF-81/001b

2.

3. Recipient's Accession No. PB81 164626

4. Title and Subtitle
User's Guide to the Texas Climatological Model

5. Report Date AUG 80

6.

7. Author(s)
Staff - Texas Air Control Board

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Texas Air Control Board
Permits Section
6330 Hwy. 290 East
Austin, TX 78723

10. Project/Task/Work Unit No. N/A

11. Contract(C) or Grant(G) No.
(C) N/A
(G) N/A

12. Sponsoring Organization Name and Address
Same as 9

13. Type of Report & Period Covered
Final

14.

15. Supplementary Notes
Fpr magnetic tape see PB81 164600

16. Abstract (Limit: 200 words)

The Texas Climatological Model Version 2 (TCM-2) is a Fortran computer program designed to predict ground-level, long-term concentrations of atmospheric pollutants. The Model uses techniques that require much less computer time than most climatological models. Predictions are based upon the steady-state Gaussian plume hypothesis, Briggs plume rise formulations, Pasquill-Gifford dispersion coefficient approximations, and exponential pollutant decay.

Long-term ground-level concentrations may be determined for one or two pollutants. Any number of point sources and area sources may be input to the model. Long-term meteorological conditions are input by a meteorological joint frequency function which gives the probability of occurrence for each of 576 different cases. Five scenarios of meteorological data and source emission inventories may be input to the model for one run. Plume rise is calculated by the most representative of six different methods and optionally can use only final rise. An option allows the simulation of dispersion found in urban areas. TCM-2 is well suited for, but not limited to, the following applications:

Stack parameter design studies.
Fuel conversion studies.
Monitoring network design
Control strategy evaluation for SIP.
Evaluation of the impact of new sources or source modifications for permit application review.
Control technology evaluation.
Prevention of significant deterioration.

17. Document Analysis a. Descriptors

Atmospheric pollution
Air pollution
Algorithms
Diffusion
models
simulation
meteorology

b. Identifiers/Open-Ended Terms
Air Quality Simulation Models (AQSM)
Air Pollutant Dispersion Models

c. COSATI Field/Group 04 02 Atmospheric Sciences/Meteorology

18. Availability Statement
Release Unlimited

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages

22. Price

i

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35)

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED FROM THE BEST COPY FURNISHED US BY THE SPONSORING AGENCY. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE.

Users' Guide

to the

TEXAS CLIMATOLOGICAL MODEL

by

Staff of the Texas Air Control Board

August 1980

Texas Air Control Board
Permits Section
6330 Hwy. 290 East
Austin, Texas 78723

TABLE OF CONTENTS

1. MODEL OVERVIEW 1
   1.1 BACKGROUND AND PURPOSE 1
   1.2 SCOPE AND USE 1
      1.2.1 Applications 1
      1.2.2 Limits of Use 2
   1.3 BASIC DEFINITIONS AND CONCEPTS 3
      1.3.1 Basic Definitions 3
      1.3.2 Concepts 5
   1.4 SUMMARY OF INPUT DATA 7
      1.4.1 Control Parameters 7
      1.4.2 Scenario Parameters 7
      1.4.3 Area Source Inventory 7
      1.4.4 Point Source Inventory 8
   1.5 SUMMARY OF MODEL OUTPUT 8

2. TECHNICAL DISCUSSION 9
   2.1 TCM-2 MODEL FORMULATION 9
   2.2 METEOROLOGICAL DISPERSION 9
      2.2.1 Point Source Algorithms 9
         2.2.1.1 Basic Assumptions 9
         2.2.1.2 Long Term Gaussian Dispersion Equation 10
         2.2.1.3 Dispersion Coefficients 11
         2.2.1.4 Meteorological Joint Frequency Function 12
         2.2.1.5 Wind Speed 12
         2.2.1.6 Wind Speed Determination 14
         2.2.1.7 Plume Rise Determination 16
         2.2.1.8 Pollutant Decay 19
         2.2.1.9 Calculations from Tabular Data . . 22
      2.2.2 Area Source Algorithms 26
   2.3 SPECIAL SOURCE APPLICATIONS 38
      2.3.1 Flares 38
      2.3.2 Small, Strong Area Sources 39
   2.4 RECEPTOR ARRAY 40
      2.4.1 Description of Receptor Grid 40
   2.5 LEAST SQUARE CALIBRATION ALGORITHM 40
   2.6 TCM-2 LIMITATIONS 42
      2.6.1 Steady State Assumption 42
      2.6.2 Dispersion Coefficients 43

2.6.3 Meteorological Joint Frequency Function . . 44
2.6.4 Limited Vertical Mixing 45
2.6.5 Downwash 46
2.6.6 Terrain Adjustment 46
2.6.7 Pollutant Depletion 46
2.6.8 Area Source Algorithm 47

List of Symbols 48

References 50

3. USERS' GUIDE 51

3.1 SUMMARY OF PROGRAM INPUTS 51
3.1.1 Control Parameters 51
3.1.2 Calibration Factors 51
3.1.3 Meteorological Joint Frequency Function . . 51
3.1.4 Area Source Inventory 51
3.1.5 Blank Card 52
3.1.6 Point Source Inventory 52
3.1.7 Blank Card 52
3.1.8 Monitoring Site Data 52
3.1.9 Blank Card 52

3.2 CONTROL PARAMETERS 54
3.2.1 Card 1 54
3.2.2 Card 2 54
3.2.3 Card 3 56
3.2.4 Card 4 59
3.2.5 Card 5 59

3.3 CALIBRATION FACTORS 59
3.3.1 Card 6 59
3.3.2 Card 7 62
3.3.3 Card 8 63
3.3.4 Card 9 63

3.4 METEOROLOGICAL JOINT FREQUENCY FUNCTION 63
3.4.1 Card 1 64
3.4.2 Each of 96 Cards 64
3.4.3 Arrangement of Cards 64

3.5 AREA SOURCE INVENTORY 65
3.5.1 Cards 65
3.5.2 Construction of Area Source Inventories . . 67

3.6 POINT SOURCE INVENTORY 69
3.6.1 Point Sources for NSRCOP=1 69
3.6.2 Point Sources for NSRCOP=2 70
3.6.3 Point Sources for NSRCOP=3 72

3.7 MONITORING SITE DATA 74
3.7.1 Cards 74

4. TCM-2 FLOW DIAGRAMS 77

Appendix A General Form of the Gaussian Equation 101

Appendix B TCM-2 Area Source Algorithm Derivation . . . 111

Appendix C Derivation of Flare Input as a Point Source . 117

Appendix D Example Print Out of Meteorological Joint Frequency Function 119

Appendix E Example of TCM-2 Area Source Calculations Done as Point Sources 123

Appendix F Example of TCM-2 Area Source Calculations . . 131

Appendix G Example of TCM-2 Point Source Calculations . 139

Appendix H TCM-2 Program Listing 149

LIST OF TABLES

1-1 Pasquill Stability Classes 4

1-2 National Weather Service Wind Speed Classes 5

2-1 Power Law Exponents and Coefficients for σ_z 13

2-2 Values Used in TCM-2 for Wind Speed Classes 15

2-3 Exponents for Adjustment of Wind Speed to Stack Height 17

2-4 Variables Used to Calculate Values of K Stored in TCM-2 Data Tables 21

2-5 Wind Direction Sectors and Indices 25

2-6 Values for a(m) and b(m) used in Equations (16) and (17) 30

2-7 Patterns of Affected Calculation Grid Squares 31

2-8 Receptor Concentrations for Calculation Grid Squares Not Listed in Table 2-7 37

4-1 List of Variables Used in the TCM-2 Flowcharts 78

LIST OF FIGURES

2-1 Plume Rise Formulae 18

2-2 Wind Direction Sectors with Indices 24

2-3 Source-Receptor Geometry 27

2-4 Relationship Between Receptor Grid and Area Source Calculation Grid 28

2-5 Patterns of Calculation Grid Squares Affected by an Area Source 32

3-1 TCM-2 Input Deck Structure 53

3-2 Control Parameters Coding Form 55

3-3 Pollutant Calibration Coding Form 60

3-4 Area and Point Source Data Coding Form - Metric Input . 66

3-5 Example of Placement of Area Sources 68

3-6 Area and Point Source Data Coding Form - English Input 71

3-7 Area and Point Source Data Coding Form - Mixed units . 73

3-8 Monitoring Site Data Coding Form 75

4-1 TCM-2 Program 79

4-2 Subroutine KCALC 92

4-3 Subroutine SECTOR 93

4-4 Subroutine REGAN 94

4-5 Subroutine ARRAY 95

4-6 Subroutine WORST 96

4-7 Subroutine WOROUT 97

4-8 Subroutine RISE 98

4-9 Subroutine MAXOUT 99

A-1 Coordinate System for the Gaussian Plume Equation . . . 102

A-2 Polar Coordinate System Used for TCM-2 103

A-3 Source, Plume, and Receptor Relationship 105

B-1 Area Source Geometry with Affected Downwind Calculation Grid Squares 114

TCM MANUAL

1. MODEL OVERVIEW

1.1 BACKGROUND AND PURPOSE

The Texas Climatological Model Version 2 (TCM-2) is a Fortran computer program designed to predict ground level, long term concentrations of atmospheric pollutants. This model uses a technique (published as the Fast Air Quality Model by Christiansen and Porter, 1975 [1]), that requires much less computer time than most climatological models. Predictions are based upon the steady state Gaussian plume hypothesis, Briggs plume rise formulations, Pasquill-Gifford dispersion coefficient approximations, and exponential pollutant decay. A few modifications and revisions have been made to the original model. The most important is a change in the area source algorithm.

1.2 SCOPE AND USE

1.2.1 Applications

The TCM-2 is a general purpose model that has many applications. Long term ground level concentrations may be determined for one or two pollutants. Any number of point sources and area sources may be input to the model. Long term meteorological conditions are input by a meteorological joint frequency function which gives the probability of occurrence for each of 576 different cases. The average temperature for the time period considered is input by the user. Five scenarios of meteorological data and source emission inventories may be input to the model for one run. For example, this capability allows the user to obtain average pollutant concentration predictions for each of the four seasons and an annual average concentration. Plume rise is calculated by the most representative of six different methods and there is an option to use only the final plume rise. Exponential decay of pollutant concentration may be calculated when requested by the user. In addition, there is an option that allows the user to simulate dispersion found in urban areas.

The TCM-2 has a subroutine that can be used to calibrate the model with observed concentrations.

The TCM-2 is well suited for, but not limited to, the following applications:

1. Stack parameter design studies.
2. Evaluation of the impact of new sources or source modifications for permit application review.
3. Fuel conversion studies.
4. Monitoring network design.
5. Control technology evaluation.
6. Control strategy evaluation for SIP.
7. Prevention of significant deterioration.

1.2.2 Limits of Use

Every dispersion model is limited by the assumptions used to predict pollutant behavior after release to the atmosphere. State of the art mathematical modeling techniques have been used throughout this model. Each predictive algorithm with limiting assumptions is discussed in detail later. General limitations are summarized as follows:

1. Sources: All sources are stationary. Up to five sets of different emission inventories may be used in the same run.

2. Meteorology: Up to five different scenarios of meteorological data may be used in each run. The meteorological joint frequency function has probabilities for 576 cases: 6 atmospheric stability classes, 6 wind speed classes, and 16 wind direction sectors.

3. Depletion mechanisms: The only depletion mechanism available in the TCM-2 is exponential decay with the users' option to input any desirable half-life. Therefore, the TCM-2 is most suited to modeling relatively nonreactive pollutants such as SO_2, CO, and particulates. The TCM-2 is not suited for modeling highly reactive pollutants such as hydrocarbons, oxidants, and oxides of nitrogen. Reflection of the plume at ground level is assumed with no depletion of the pollutants.

4. Terrain: The TCM-2 does not make an adjustment for differences in terrain elevation between sources and/or receptors.

1.3 BASIC DEFINITIONS AND CONCEPTS

1.3.1 Basic Definitions

Air Contaminants - An air contaminant is particulate matter, dust, fumes, gas, mist, smoke, vapor or odor or any combination thereof produced by processes other than natural.

Air Pollution - Air pollution is the presence in the atmosphere of one or more air contaminants or combinations thereof, in concentration and of such duration as are or may tend to be injurious to, or to adversely affect human health or welfare, animal life, vegetation or property, or as to interfere with the normal use and enjoyment of animal life, vegetation, or property.

Dispersion Model - A dispersion model is a mathematical description of the meteorological transport and turbulent diffusion processes that affect pollutants emitted to the atmosphere. Usually a model will predict pollutant concentrations at some point of interest (receptor) from inputs of meteorological data, source data, and receptor location.

Stationary Sources - Stationary sources are pollution emission sources for which emissions can be identified with a plant or an area that remains geographically fixed.

Point Source - A point source is a single, identifiable stack that emits one or more pollutants at a defined rate. Normal parameters for dispersion model input are: pollutant emission rates, stack height, stack diameter, exit velocity, exit temperature, and location.

Area Source - An area source is a source of pollutants that is not identifiable as a point source. Typical examples of area sources are: a lagoon, a dump or solid waste disposal site, the side or large area of a building, an unpaved road or parking area, valves, vents, etc. Frequently, these are also called sources of fugitive emissions. In practice, it is often difficult to accurately define emissions from area sources. These sources are normally considered to emit pollutants at ground level.

Receptor - A receptor is a point on the ground at which the ambient air quality (pollutant concentration) is to be determined.

Receptor Grid - A receptor grid is a rectilinear set of adjacent squares of equal size with a receptor located at the intersection of each grid column and row. The TCM-2 can handle up to 2500 receptors in a 50 x 50 grid.

Scenario - A scenario is a set of meteorological conditions that are input to the model to be used to predict pollutant concentrations at each receptor in the grid. These data are used to characterize the transport and turbulent diffusion properties of the atmosphere. Meteorological data input for the TCM-2 are the values for the meteorological joint frequency function and average temperature.

Advection - Advection is the process of transport of an air parcel by the mean velocity field of the atmosphere. Advection is represented in the model by the azimuth of the wind.

Diffusion - Diffusion in the atmosphere is the exchange of mass between regions in space. Diffusion in the lower atmosphere is dominated by eddy exchange due to turbulent air movements, the magnitude of which is generally a function of atmospheric stability.

Turbulence - Turbulence is a state of fluid flow in which fluid particles (small masses) move in random, irregular paths. Instantaneous velocities exhibit irregular and random fluctuation.

Atmospheric Stability - Atmospheric stability characterizes the thermodynamic and mechanical influences present in the structure of the atmosphere. Frequently, it is oversimply defined by comparison of actual temperature lapse rate with the "dry adiabatic" lapse rate. Table 1-1 lists the stability classes used in the TCM-2.

Table 1-1

Pasquill Stability Class		TCM-2 Nomenclature
A	extremely unstable	1
B	moderately unstable	2
C	slightly unstable	3
DD	neutral - day	4
DN	neutral - night	5
E	slightly stable	6
F	moderately stable	6

Mixing Height - The turbulent air near the ground is frequently bounded above by a layer of stable air. The distance from the ground to the bottom of the stable layer is the mixing height. The stable layer virtually prevents vertical dispersion above the mixing height.

Wind Speed Class - The National Weather Service has selected 6 classes to describe wind speed. These 6 classes along with the central wind speed [2] of each class are listed in Table 1-2.

Table 1-2

National Weather Service Wind Speed Classes

NWS Wind Speed Class	Speed Interval, Knots	Central Wind Speed meters/second
1	<3	1.50
2	4-6	2.46
3	7-10	4.47
4	11-16	6.93
5	17-21	9.61
6	>21	12.52

Wind Direction Sector - The 360 degrees are divided into 16 equally sized 22.5 degree sectors. The wind direction at any given time is within one of these sectors. Wind direction sectors are used to define wind direction in order to decrease computation time.

Sector Averaging - At any time the wind direction will fall within one of the 16 equally sized wind direction sectors. Over a period of time all wind direction observations can be placed in a wind direction sector and the number of occurrences within each sector tabulated. Then the probability for the wind direction occurring in any sector can be determined. It is assumed that there is a uniform distribution of wind direction within each sector. This results in a uniform horizontal distribution of the plume within each sector. The probability that the wind direction will be in a sector is described by the joint meteorological frequency function.

Meteorological Joint Frequency Function - This is a function that describes the probability of occurrence for each of 576 cases of three meteorological parameters. This function is specific for each geographical location and time period. Values for this function are derived from historical meteorological data. The parameters considered are: 6 wind speed classes, 16 equally sized wind direction sectors, and 6 atmospheric stability classes (6 x 16 x 6 = 576).

1.3.2 Concepts

The TCM-2 takes a specific set of input data and predicts long term pollutant concentrations at each receptor in a predefined grid. Input requirements are source parameters for each point and area source, receptor grid location, meteorological data, pollutant half-life, and measured concentrations with locations if the model is to be calibrated. Receptor grid inputs define the location and size of the receptor grid. Meteorological inputs include average temperature and the values for the meteorological joint frequency functions for each scenario.

The TCM-2 has five basic parts. The first part performs calculations to reduce the number of entries for the meteorological joint frequency function to 96.

The second part of the TCM-2 determines concentrations from area sources. This algorithm is based upon one developed by Gifford and Hanna.

The third part calculates concentrations from point sources and includes plume rise and diffusion algorithms. Plume rise is determined by the most representative of six different methods developed by Briggs. Either buoyancy or momentum dominated plume rise can be determined. There is a user option to use only the final plume rise for calculations. Neither stack-tip downwash of the plume nor building downwash is included. Plume transport and diffusion are modeled with a version of the Gaussian plume dispersion model. This model uses vertical dispersion coefficients developed by Pasquill and Gifford that relate dispersion to atmospheric stability and distance downwind from the source. The method of sector averaging is used to describe dispersion in the horizontal direction. This data is input to the model in the form of a meteorological joint frequency function. There is also a user option to simulate dispersion found in urban areas.

The fourth part of the TCM-2 predicts pollutant decay. The decay is exponential based upon travel time with the half-life of the pollutant input by the user.

The fifth part of the TCM-2 calibrates the model using measured concentrations input by the user. A least squares fit analysis is used to determine a multiplying factor to apply to model predictions.

1.4 SUMMARY OF INPUT DATA

Input into the TCM-2 can be divided into four sections:

1.4.1 Control Parameters

Control parameters remain constant throughout the model run. These parameters include:

1. Receptor Grid
    - (a) Size of grid in number of columns and number of rows
    - (b) Location of west grid boundary and of south grid boundary
    - (c) Spacing of columns and rows
2. Number of pollutants
3. Output options
    - (a) List of concentrations at each receptor
    - (b) Concentration map (none, calibrated and/or uncalibrated)
    - (c) Punched card output
    - (d) Culpability list (lists five highest contributors at each receptor)
    - (e) List of maximum concentrations for each scenario.

1.4.2 Scenario Parameters

From one to five scenarios may be used for each run. Each scenario uses a separate set of point source and area source inventories. The same receptor grid is used for all scenarios.

Meteorological inputs for each scenario are:

1. Average temperature
2. Values for meteorological joint frequency function

1.4.3 Area Source Inventory

A separate inventory is needed for each scenario, so emission rates and other parameters can be varied. For each area source the following are input:

1. Coordinates of south and west boundary of the source
2. Source size

3. Emission rate for each pollutant
4. Identification

1.4.4 Point Source Inventory

A separate inventory is needed for each scenario, so emission rates and other parameters can be varied. For each point source the following are input:

1. Source coordinates
2. Emission rates for each pollutant
3. Stack height
4. Stack diameter
5. Stack velocity
6. Stack temperature
7. Identification

1.5 SUMMARY OF MODEL OUTPUT

Output options are as follows:

1. Concentration List Option. All concentrations and coordinates at each grid receptor are printed one column per page.

2. Spatial Array Option. Concentrations in a map form display are printed. One, two, or four printed pages may be required per map. Calibrated or uncalibrated concentrations or both may be printed.

3. Punched Card Option. The concentrations and receptor coordinates for each receptor are punched onto cards. This option is for input to a contour plotting routine.

4. Culpability List Option. The percent contribution and source number are printed for the five highest contributors at each receptor.

5. Maximum Concentration Option. The maximum concentration for each scenario is printed.

2. TECHNICAL DISCUSSION

2.1 TCM-2 MODEL FORMULATION

The Texas Climatological Model Version 2 (TCM-2) is designed to predict ground level, long-term concentrations of atmospheric pollutants. Calculations are based on the steady state Gaussian plume equation, Briggs plume rise formulations for buoyant and momentum dominated plumes, the empirically derived Pasquill-Gifford vertical dispersion coefficients, and a meteorological joint frequency function. For each run, time averaged concentrations may be determined for up to 5 different scenarios, each of which can cover different time periods and have different source inventories. Annual and/or seasonal averages are most frequently determined. Concentrations are determined for a rectilinear array of receptors whose size and location is defined by the user. Both area and point sources may be used. The user may elect to use only final plume rise. Rural or urban dispersion may be used. An option to calculate exponential pollutant decay may be used. When desired, a least squares fit subroutine may be used to adjust the model output using measured concentrations. This chapter presents in detail the technical basis of each component of the model along with references where appropriate.

2.2 METEOROLOGICAL DISPERSION

2.2.1 Point Source Algorithms

1. Basic Assumptions. The steady state Gaussian plume equation is based upon the following assumptions:

a. The emission rate is constant and dispersion occurring in the downwind direction is negligible compared to advection.

b. The pollutants are transported downwind at an appropriate average wind speed. With the use of one average wind speed and constant wind direction, one assumes that the horizontal wind field is homogeneous and the effects of directional wind shear are neglected. Wind speed is adjusted to the physical stack height.

c. There is no directional wind shear in the vertical.

d. The plume is infinite with no plume history. (e.g. the effects of a sudden change in wind direction are ignored)

e. The pollutants are non-reactive gases or aerosols and remain suspended in the air following the turbulent movement of the atmosphere.

f. The plume is reflected at the earth's surface with no pollutant losses due to reaction or deposition at the surface.

g. Pollutants are dispersed by atmospheric turbulence and to a much lesser extent by molecular diffusion. The concentrations in both the crosswind and the vertical directions take the form of Gaussian distributions about the plume centerline.

Additional Assumptions. The long term equation used in TCM-2 was derived from the steady state Gaussian plume equation. The additional assumptions are:

h. Crosswind dispersion is described by sector averaging instead of by a Gaussian distribution. A meteorological joint frequency function is used to describe dispersion in the crosswind direction. Sixteen equally sized sectors are used for wind direction. It is assumed that the wind will blow from each direction within a sector with the same frequency.

2. Long Term Gaussian Dispersion Equation. The long term Gaussian dispersion equation was derived from the steady state Gaussian plume equation (equation 18 in Appendix A). Using the long term equation, the average ground level concentration C_ρ (in micrograms per cubic meter) at a point meters from the stack in the k th wind direction sector may be written as:

$$C_\rho(k,\rho) = \frac{32 \times 10^6 Q}{(2\pi)^{3/2}\rho} \left\{ \frac{\Phi(k,m)}{U^*(H,m)\ \sigma_z(m)} \exp\left[\frac{H^2}{-2\sigma_z(m)2}\right] \right\} \qquad (1)$$

where

Q is the source emission rate, grams per second

ρ is the distance from the stack to the receptor, meters

Φ (k,m) is the meteorological joint frequency function

k is the index of wind direction sector which contains the vector from the source to the point considered

m is the index for the atmospheric stability class

$U^*(H,m)$ is the weighted averaged wind speed for stability class m at stack height H, meters per second

$\sigma_z(m)$ is the standard deviation of the concentration distribution in the vertical direction, meters

H is the effective stack height, which is the sum of stack height and plume rise, meters

The derivation of equation (1) is shown in Appendix A.

3. Dispersion Coefficients. The vertical dispersion coefficients, σ_z, used in the TCM-2 are identical to those used in EPA's Climatological Dispersion Model [2]. Values for σ_z were derived from power law equations fit to the σ_z curves reported by Turner [3]. The curves themselves were derived from empirical data by Pasquill [4] and Gifford [5]. The values of these coefficients are a function of atmospheric stability class and distance downwind from the source.

The σ_z curves determined by Pasquill and Gifford were derived from measurements taken in open, level to gently rolling terrain and may not be the best estimate of dispersion coefficients for urban areas or areas with rough terrain. For area sources, when the urban dispersion option is used, calculations are made by decreasing each atmospheric stability class index by one, except for Class A. For point sources, when the urban option is used, calculations for atmospheric stability classes E and F (stable conditions) are made with values for stability class DN.

The vertical standard deviation function may be approximated by a power curve as follows:

$$\sigma_z = a(m)\ \rho^{b(m)} \qquad (2)$$

Where: a(m) and b(m) are functions of atmospheric stability class index m and are partially dependent upon downwind distance. The values of a(m) and b(m) used in TCM-2 were determined by Busse and Zimmerman [2] for use in the Climatological Dispersion Model (CDM). These values are listed in Table 2-1.

4. Meteorological Joint Frequency Function

If wind speed, wind direction, and atmospheric stability are considered as random variables, the probability of occurrence of any combination of these variables can be described by a joint frequency function. To make the definition of the joint frequency function practical, the continuum of values for each of the three random variables is divided into discrete classes. Six wind speed classes, sixteen equally sized wind direction sectors, and six atmospheric stability classes are used in the TCM-2. This gives a total of 576 combinations (6 x 16 x 6 = 576). To further simplify TCM-2 calculations a weighted average wind speed for each atmospheric stability class is determined. Then for all wind direction sectors within each atmospheric stability class this weighted average wind speed is used for all calculations involving wind speed. Thus the meteorological joint frequency function depends upon sixteen wind direction sectors and six stability classes and has 96 possible cases (6 x 16 = 96). This function is denoted by $\phi(k, m)$ where k is the wind direction sector index and m is the atmospheric stability class index.

5. Wind Speed

The National Weather Service has defined six wind speed classes. The central wind speed [2] of each class is used in the TCM-2. These central wind speeds represent measurements taken at "ground level".

TABLE 2-1

Power Law Exponents and Coefficients for σ_z

Atmospheric Stability Class	Downwind Distance, meters $100 < x \leq 500$		Downwind Distance, meters $500 < x \leq 5000$		Downwind Distance, meters $5000 < x$	
	a	b	a	b	a	b
A=1	.0383	1.281	.0002539	2.089	.0002539	2.089
B=2	.1393	.9467	.04936	1.114	.04936	1.114
C=3	.1120	.9100	.1014	.926	.1154	.9109
DD=4	.0856	.8650	.2591	.6869	.7368	.5642
DN=5	.0818	.8155	.2527	.6341	1.297	.4421
E and F	.0545	.8124	.2017	.6020	1.5763	.3606

To adjust for erroneously reported calms, the value for the Class 1 wind speed is arbitrarily selected. Values used in the TCM-2 are the ones used in CDM [2] and are listed in Table 2-2.

The TCM-2 uses a weighted average wind speed for each atmospheric stability class. The weighted average wind speed, U*(m), for stability class m is defined as:

$$U^*(m) = \frac{\sum_{k=1}^{16} \sum_{\ell=1}^{6} \Phi(k,\ell,m)}{\sum_{k=1}^{16} \sum_{\ell=1}^{6} \frac{\Phi(k,\ell,m)}{U_\ell}} \quad (3)$$

Where:

$\Phi(k,\ell,m)$	is the meteorological joint frequency function
k	is the wind sector index
ℓ	is the wind speed class index
m	is the atmospheric stability class index
U_ℓ	is the central wind speed for wind speed class ℓ

6. Wind Speed Determination

In the lower layers of the atmosphere, wind speed normally increases with height. Most National Weather Service wind speed measurements are taken at a height of 10 meters above the surface and are listed as "ground level" wind speeds. The wind speed at stack height has the greatest effect on the plume, and this wind speed is normally greater than that at ground level.

The following well-accepted function is used in the TCM-2 to adjust the ground level weighted average wind speed for each atmospheric stability class to stack height:

$$U^*(H,m) = U^*(m)\left(\frac{H}{z_o}\right)^{P(m)} \quad (4)$$

TABLE 2-2

Values Used in TCM-2 for Wind Speed Classes

NWS Wind Speed Class	Speed Interval, Knots	Central Wind Speed Value, meters/second
1	<3	1.50
2	4-6	2.46
3	7-10	4.47
4	11-16	6.93
5	17-21	9.61
6	>21	12.52

Where:

$U^*(H, m)$	is the weighted average wind speed for atmospheric stability class index m at stack height H
$U^*(m)$	is the weighted average wind speed for atmospheric stability class m at anemometer height
z_0	is the anemometer height (assumed to be 10 meters)
$P(m)$	is a function of atmospheric stability class index m with values defined in Table 2-3

The values of P(m) in Table 2-3 were determined by De Marris [6].

In the layer below 10 meters, the surface roughness parameter generally affects wind speed more than atmospheric stability class. Thus, for stacks whose height is less than 10 meters, the wind speed at 10 meters is used. This prevents the use of unrealistically low wind speeds.

7. Plume Rise Determination

Plume rise is determined from equations derived by Briggs [7, 8, 9, 10]. For atmospheric stability classes A through D, the neutral/unstable plume rise equations are used. For stability classes E and F, the stable plume rise equations are used. Stack diameter, stack exit velocity, stack exit temperature, and ambient temperature indicate whether the upward motion of the plume is dominated by momentum or thermal buoyancy. There are four different situations for plume rise: (1) stable atmosphere with buoyancy dominated plume, (2) stable atmosphere with momentum dominated plume, (3) neutral/unstable atmosphere with buoyancy dominated plume, (4) neutral/unstable atmosphere with momentum dominated plume. In each situation, except for a stable atmosphere with a momentum dominated plume, plume rise is calculated as a function of downwind distance from the source until the final plume rise is obtained. There is a user option to use only final plume rise for all calculations.

TABLE 2-3

Exponents for Adjustment of Wind Speed to Stack Height

Atmospheric Stability Class Index m	P(m)
A=1	0.10
B=2	0.15
C=3	0.20
DD=4	0.25
DN=5	0.25
E & F=6	0.30

	STABLE ATMOSPHERE	NEUTRAL/UNSTABLE ATMOSPHERE
BUOYANCY DOMINATED	$\Delta h(x) = 1.6F^{1/3}x^{2/3}U^{-1}$ (4) or $\Delta h_{MAX} = 2.6(F/Us)^{1/3}$ (5) where $s = .02g/T_A$ for E and F stability	$\Delta h(x) = 1.6F^{1/3}x^{2/3}U^{-1}$ (4) for $x < 3.5x^*$ or $\Delta h_{MAX} = 1.6F^{1/3}(3.5x^*)^{2/3}U^{-1}$ (6) for $x > 3.5x^*$ where $x^* = 14F^{5/8}$ if $F < 55$ $x^* = 34F^{2/5}$ if $F > 55$
MOMENTUM DOMINATED	$\Delta h_{MAX} = 1.5(VR)^{2/3}U^{-1/3}s^{-1/6}$ (7) where s is defined as above	$\Delta h(x) = 3.78\left(\frac{V^2}{U(V+3U)}\right)^{2/3}\left(\frac{xR^2}{2}\right)^{1/3}$ (8) or $\Delta h_{MAX} = 3VD/U$ (9)

$F = gVR^2(T - T_A)/T$

T = source temperature, °K

T_A = ambient temperature, °K

V = stack exit velocity, m/s

R = stack radius, m

D = stack diameter, m

x = downwind distance, m

U = wind speed at physical source height, m/s

g = acceleration due to gravity 9.8 m/s^2

Δh = plume rise, m

Δh_{MAX} = final plume rise, m

Figure 2-1 Plume Rise Formulae

The Briggs plume rise equations used in TCM-2 are listed in Figure 2-1. For each stack, both momentum and buoyancy dominated final plume rises are calculated. The subroutine selects the higher of these two values to reflect whether momentum or thermal buoyancy dominates plume rise. The determination of the appropriate plume rise equation is performed for each atmospheric stability class in each scenario. Then, for each stack the plume rise is calculated based upon the selected plume rise equation. The effective stack height, H, is the sum of the stack height, h, and the plume rise Δh.

8. Pollutant Decay

There are many mechanisms that remove or alter airborne pollutants. Examples are absorption and chemical reaction. A simple way to approximate the effect of atmospheric depletion mechanisms is to assume that the decay is an exponential function of time. That is

$$\chi_t = \chi_o \exp(-at) \qquad (10)$$

where:

χ_t is the pollutant concentration at time t

χ_o is the pollutant concentration without decay

a is a suitable constant

t is the time since release of the pollutant in seconds

A half-life for the pollutant may be used to determine values for the constant in equation (10). Then

$$a = \frac{0.692}{t_{1/2}} \qquad (11)$$

where $t_{1/2}$ is the pollutant half-life in seconds.

Furthermore, t can be determined by

$$t = \frac{x}{U} \qquad (12)$$

where:

x is downwind distance in meters

U is average wind speed at release point in meters/second

Combining equations (10), (11), and (12)

$$\chi_t = \chi_o \exp\left(- \frac{0.692x}{U\, t_{1/2}}\right)$$

For TCM-2 calculations, half-life values are input for each pollutant. To save computation time, twenty decay factors are calculated for each pollutant and for each scenario. The distances used are those used for determination of K(ρ,H,m) and are listed in Table 2-4. Since the decay factor does not normally change rapidly with distance, there is no interpolation between the twenty calculated values. Thus, the decay multiplier remains constant between the tabular values for downwind distance.

The decay factor is

$$D(\rho, H, m) = \exp\left[\frac{-0.692\rho}{U^*(H,m)\, t_{1/2}}\right]$$

TABLE 2-4

Variables Used to Calculate Values of K Stored In TCM-2 Data Tables

Index i	Distance ρ,meters	Index j	Effective Stack Height H, meters	Index m	Stability Class S
1	1.1	1	10	1	A
2	1.4	2	15	2	B
3	1.7	3	20	3	C
4	2.1	4	25	4	D/Day
5	2.5	5	30	5	D/Night
6	3.5	6	35	6	E & F
7	4.8	7	40		
8	6.4	8	45		
9	8.3	9	50		
10	10.6	10	70		
11	13.3	11	100		
12	16.4	12	150		
13	20.0	13	200		
14	24.1	14	300		
15	28.7	15	450		
16	33.9	16	700		
17	39.7	17	1000		
18	46.1	18	1400		
19	53.2	19	2000		
20	61.0				

9. Calculations From Tabular Data

For each source-receptor combination, the TCM-2 is able to calculate pollutant concentrations very rapidly. The calculation uses a numerical technique developed by Christiansen and Porter [1] that was first used in the TCM-1. Let

$$K(\rho, H, m) = \frac{32 \times 10^6}{(2\pi)^{3/2} \rho \, \sigma_z} \exp \left[- \frac{H^2}{2\sigma_z{}^2} \right] \qquad (14)$$

where:

ρ is the distance from the stack, meters

H is the effective stack height, meters

m is the atmospheric stability class index

σ_z is the vertical dispersion coefficient, which is a function of ρ and m

K was calculated for each atmospheric stability class using 20 values for ρ and 19 values for H. The specific values of variables used for calculations of K values are shown in Table 2-4. The calculated K values for each of the 2280 (20 x 19 x 6) different combinations of variables are stored in the KPS data table in TCM-2.

For retrieval purposes, subscripts for K values are i, j, and m.

The smallest value for the effective stack height is 10 meters and the largest value is 2000 meters. Sources with effective stack heights less than 10 meters are assigned an effective stack height of 10 meters and those whose effective stack height exceeds 2000 meters are assigned an effective stack height of 2000 meters.

The maximum downwind distance used for calculation of K values is 61 kilometers. Sources that are located in excess of 61 kilometers upwind of a receptor are disregarded. For receptors located closer than 1.1 kilometers from a source, K values are calculated explicitly using equation (14).

Concentrations at each receptor are determined by calculating concentrations at each receptor due to the first point source, then adding the corresponding concentrations for each successive point source.

The concentration at a receptor for a given point source is

$$\chi(x,y) = Q \sum_{m=1}^{6} \frac{K(\rho,H,m)\Phi(k,m)D(\rho,H,m)}{U^*(H,m)} \qquad (15)$$

where all terms are as defined before.

Values for K(ρ,H,m) are calculated by subroutine KCALC. Where appropriate the K(ρ,H,m) value is determined by linear interpolation between stored KPS table entries. Interpolation is performed on both stack height and the distance between the source and the receptor.

The 360 degrees are divided into 16 equally sized wind direction sectors. Each sector is centered on one of the 16 azimuths that represent each sector as illustrated in figure 2-2. Each of the 16 wind direction azimuths has been assigned an index as shown in table 2-5 and illustrated in figure 2-2.

The value for Φ(k,m) is dependent upon the location of the receptor relative to the point source. The azimuth from the point source to the receptor is determined and the value for k is chosen to be the index for the nearest wind direction sector. See Figure 2-3. For example if the azimuth is between 348.75° and 11.25° the index for k is 1.

An example of a typical calculation is included. In this case let the point source have an effective stack height of 55 meters with C atmospheric stability. A receptor is chosen that is 9 kilometers from the source and the azimuth from the source to the receptor is 37°. For the distance ρ, values for K at 8.3 and 10.6 kilometers are listed in the KPS data tables. Table entries are listed for effective stack heights of 50 and 70 meters. Thus for C stability class the K value will be determined by interpolating

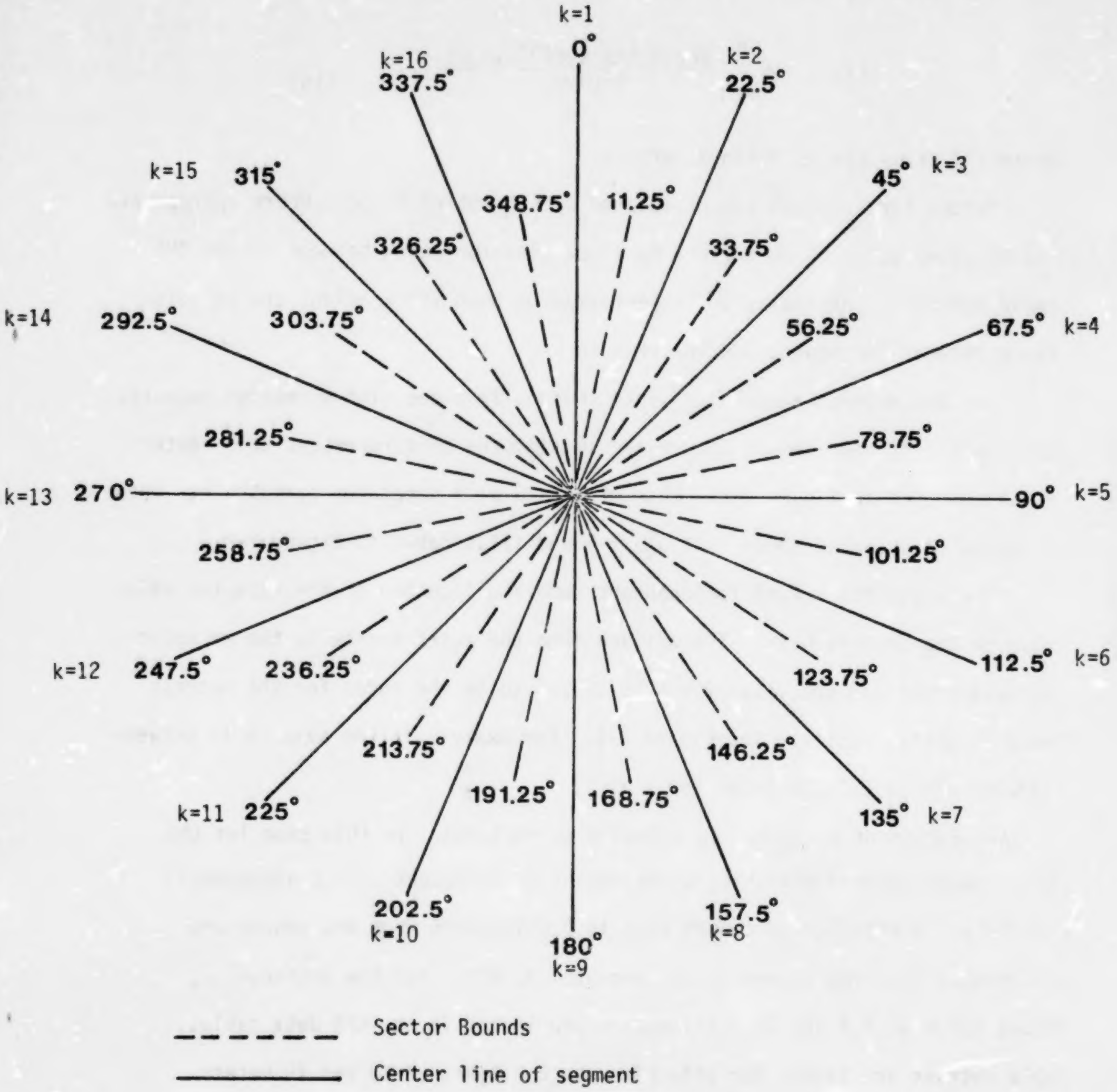


Figure 2-2 Wind Direction Sectors with Indices.

TABLE 2-5

Wind Direction Sectors and Indices

Wind Direction Sector	Representative Azimuth	Index
348.75° - 11.25°	0°	1
11.25° - 33.75°	22.5	2
33.75° - 56.25°	45°	3
56.25° - 78.75°	67.5°	4
78.75° - 101.25°	90°	5
101.25° - 123.75°	112.5°	6
123.75° - 146.25°	135°	7
146.25° - 168.75°	157.5°	8
168.75° - 191.25°	180°	9
191.25° - 213.75°	202.5°	10
213.75° - 236.25°	225	11
236.25° - 258.75°	247.5°	12
258.75° - 281.25°	270°	13
281.25° - 303.75°	292.5°	14
303.75° - 326.25°	315°	15
326.25° - 348.75°	337.5°	16

between K table entries K(9, 9, 3), K(9, 10, 3), K(10, 9, 3) and K(10, 10, 3). The source to receptor azimuth of 37° lies between 33.75° and 56.25° so the wind sector index is 3. The value for $\Phi(3,3)$ is determined. Next, the predetermined values of $D(\rho,H,m)$ and $U^*(H,m)$ are used in equation 15 to determine the source contribution with C stability. The corresponding contribution for all other stability classes is similarly determined. Then the next receptor is considered. When calculations have been made at all receptors, the same process is repeated to evaluate emissions from the next point source.

2.2.2 Area Source Algorithms

The TCM-2 calculates area source pollutant contributions with an algorithm based upon a method developed by Gifford and Hanna [11]. For area sources, the TCM-2 performs a coordinate axis translation. The new grid, called the "calculation grid", is defined by shifting the receptor grid one-half of the grid square distance to the South and one-half of the grid square distance to the West. Then a receptor is located at the center of each calculation grid square as shown in Figure 2-4. Note that receptor grid squares are the same size as calculation grid squares. Each area source should be sized so that it covers an integral number of calculation grid squares. It is advisable to define the receptor grid squares, and hence, the calculation grid squares, so that the smallest area source is at least as large as a receptor grid square.

The relationship between area sources and calculation grid squares can be divided into three cases. In the first case, the area source is the size of a calculation grid square. Emissions are assumed to be located at the center of the square. Area source contributions are determined for the center of the calculation grid square (at a receptor) containing the source and at the center of each of four squares downwind of the source.

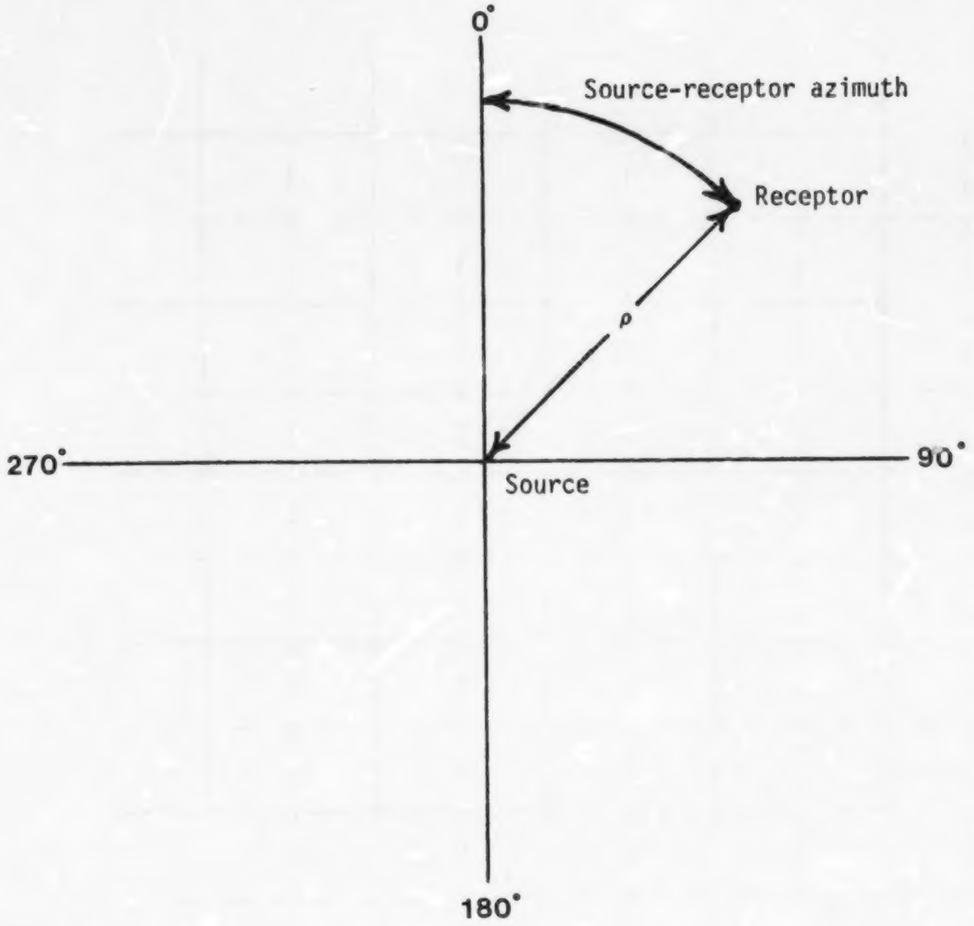


Figure 2-3 Source-Receptor Geometry

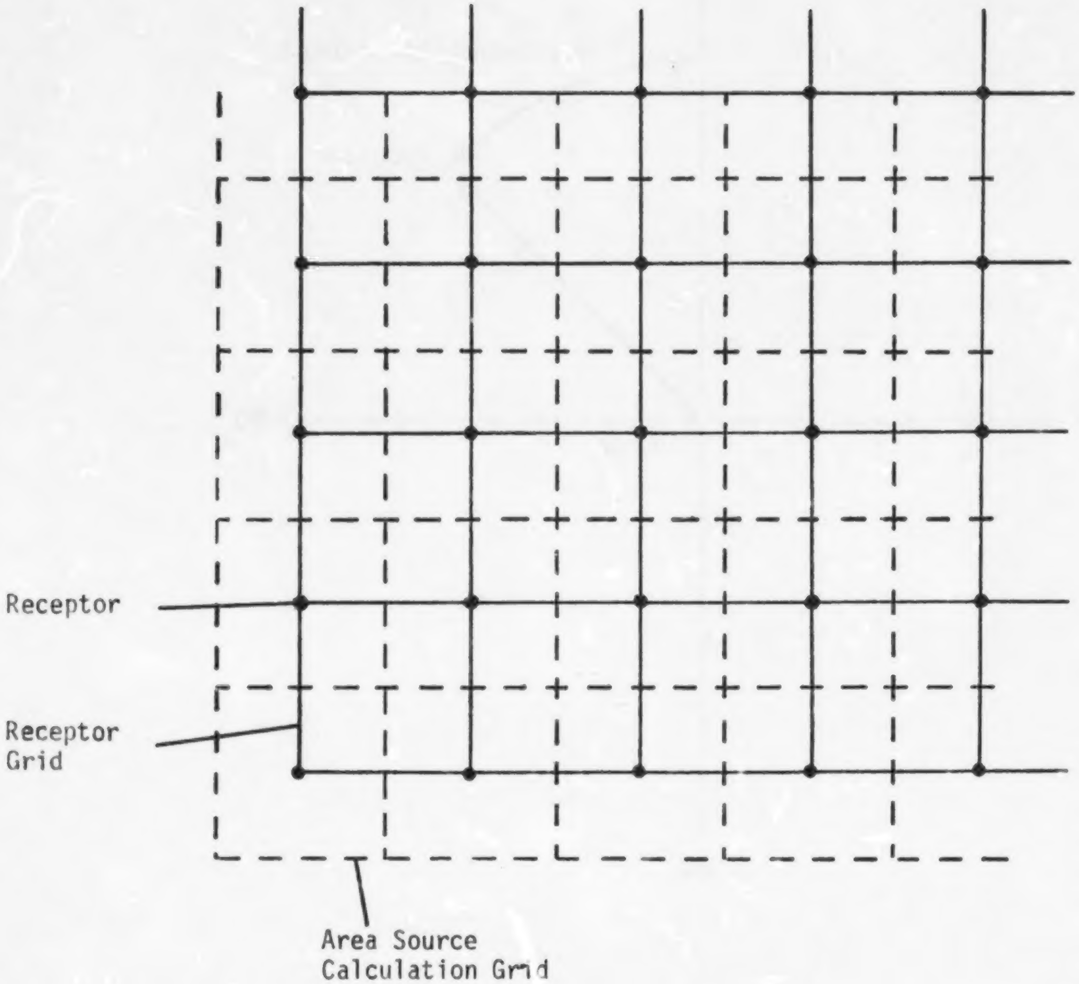


Figure 2-4 Relationship Between Receptor Grid and Area Source Calculation Grid

The equation for the pollutant concentration in the center of the square containing the area source is

$$X = \sqrt{\frac{2}{\pi}} \frac{Q\ (\Delta x/2)^{1-b(m)}}{U^{*}(m)a(m)\ [1-b(m)]} \Phi(k,m) \qquad (16)$$

where

U*(m) is the weighted average wind speed (measured at a height of 10 meters) for stability class m, meters/second

Δx is the receptor (calculation) grid spacing, meters

a(m) and b(m) are functions of atmospheric stability class m. Values used in this calculation were determined by Gifford and Hanna [11] and are reported in Table 2-6.

Q is the area source emission rate, gm/km^2-sec.

Φ (k,m) is the meteorological joint frequency function

k is the wind sector index

The pollutant concentration in the i th (i=1, 2, 3, 4) square from the area source is:

$$X = \sqrt{\frac{2}{\pi}} \frac{Q\ (\Delta x/2)^{1-b(m)}}{U^{*}(m)\ a(m)[1-b(m)]} \left[(2i+1)^{1-b(m)} - (2i-1)^{1-b(m)}\right] \Phi(k,m) \qquad (17)$$

All symbols are as defined in equation (16) above. The derivation of equations (16) and (17) is shown in Appendix B.

The meteorological joint frequency function has values for 16 wind direction sectors, each centered on a representative wind direction as shown in Table 2-5 and illustrated in Figure 2-2. The pattern of the four calculation grid squares affected by an area source is different for each wind direction sector. The pattern of affected calculation grid squares is shown in Table 2-7 and illustrated in Figure 2.5.

TABLE 2-6

Values for a(m) and b(m) Used in Equations (16) and (17)

Atmospheric Stability Class	a(m)	b(m)
A=1	0.40	0.91
B=2	0.33	0.86
C=3	0.22	0.80
DD=4	0.15	0.75
DN=5	0.06	0.71
E & F=6	0.06	0.71

TABLE 2-7

Patterns of Affected Calculation Grid Squares

Wind Direction Sector Index, k	Receptor Coordinates for Square 1*	Receptor Coordinates for Square 2	Receptor Coordinates for Square 3	Receptor Coordinates for Square 4
1	(x, y+1)	(x, y+2)	(x, y+3)	(x, y+4)
2	(x, y+1)	(x+1, y+2)	(x+1, y+3)	(x+2, y+4)
3	(x+1, y+1)	(x+2, y+2)	(x+3, y+3)	(x+4, y+4)
4	(x+1, y)	(x+2, y+1)	(x+3, y+1)	(x+4, y+2)
5	(x+1, y)	(x+2, y)	(x+3, y)	(x+4, y)
6	(x+1, y)	(x+2, y-1)	(x+3, y-1)	(x+4, y-2)
7	(x+1, y-1)	(x+2, y-2)	(x+3, y-3)	(x+4, y-4)
8	(x, y-1)	(x+1, y-2)	(x+1, y-3)	(x+2, y-4)
9	(x, y-1)	(x, y-2)	(x, y-3)	(x, y-4)
10	(x, y-1)	(x-1, y-2)	(x-1, y-3)	(x-2, y-4)
11	(x-1, y-1)	(x-2, y-2)	(x-3, y-3)	(x-4, y-4)
12	(x-1, y)	(x-2, y-1)	(x-3, y-1)	(x-4, y-2)
13	(x-1, y)	(x-2, y)	(x-3, y)	(x-4, y)
14	(x-1, y)	(x-2, y+1)	(x-3, y+1)	(x-4, y+2)
15	(x-1, y+1)	(x-2, y+2)	(x-3, y+3)	(x-4, y+4)
16	(x, y+1)	(x-1, y+2)	(x-1, y+3)	(x-2, y+4)

*For this table the coordinates of the center of the area source are (x, y). The coordinates of the receptor in the first square to the north of the area source are (x, y+1).

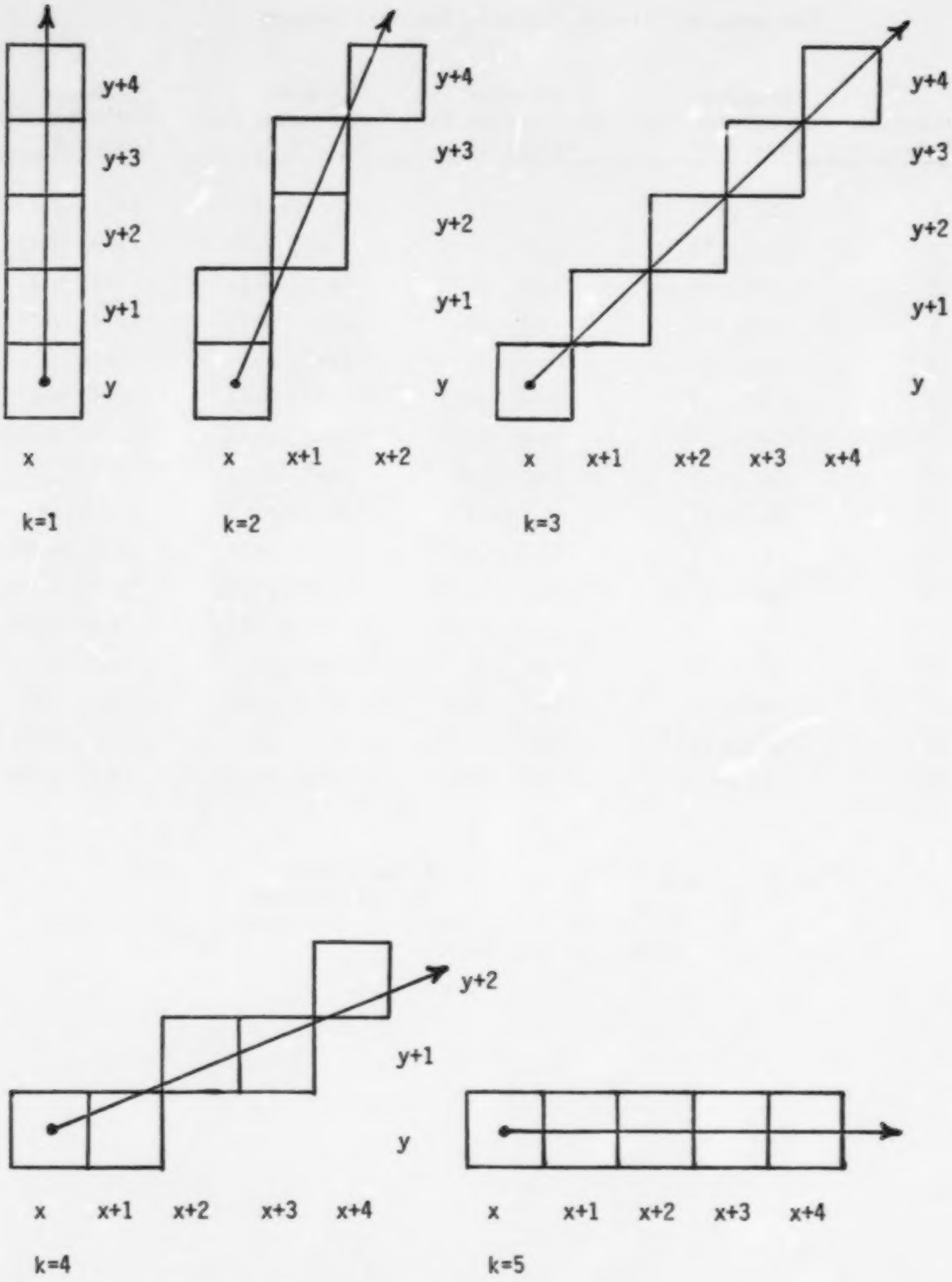
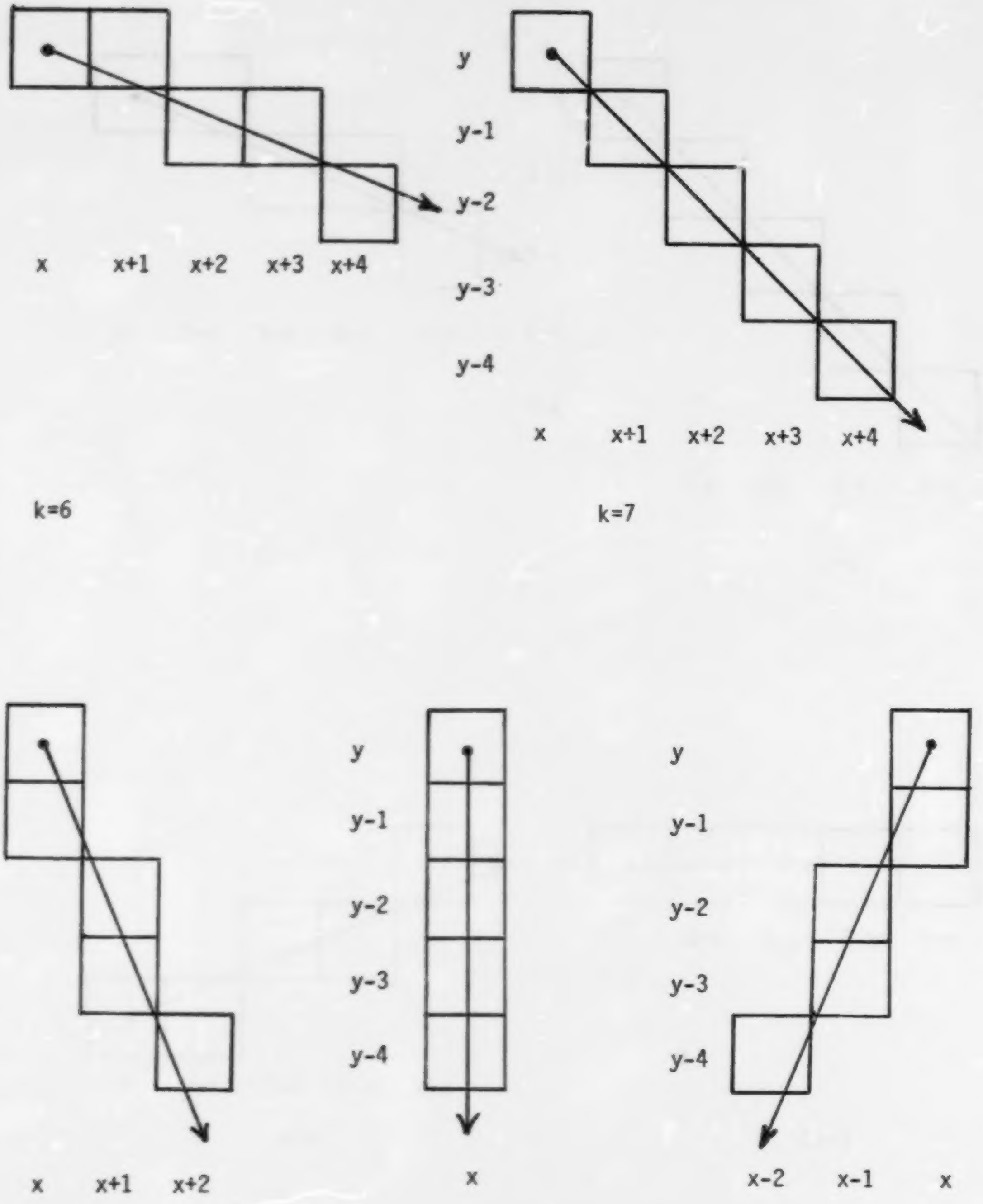


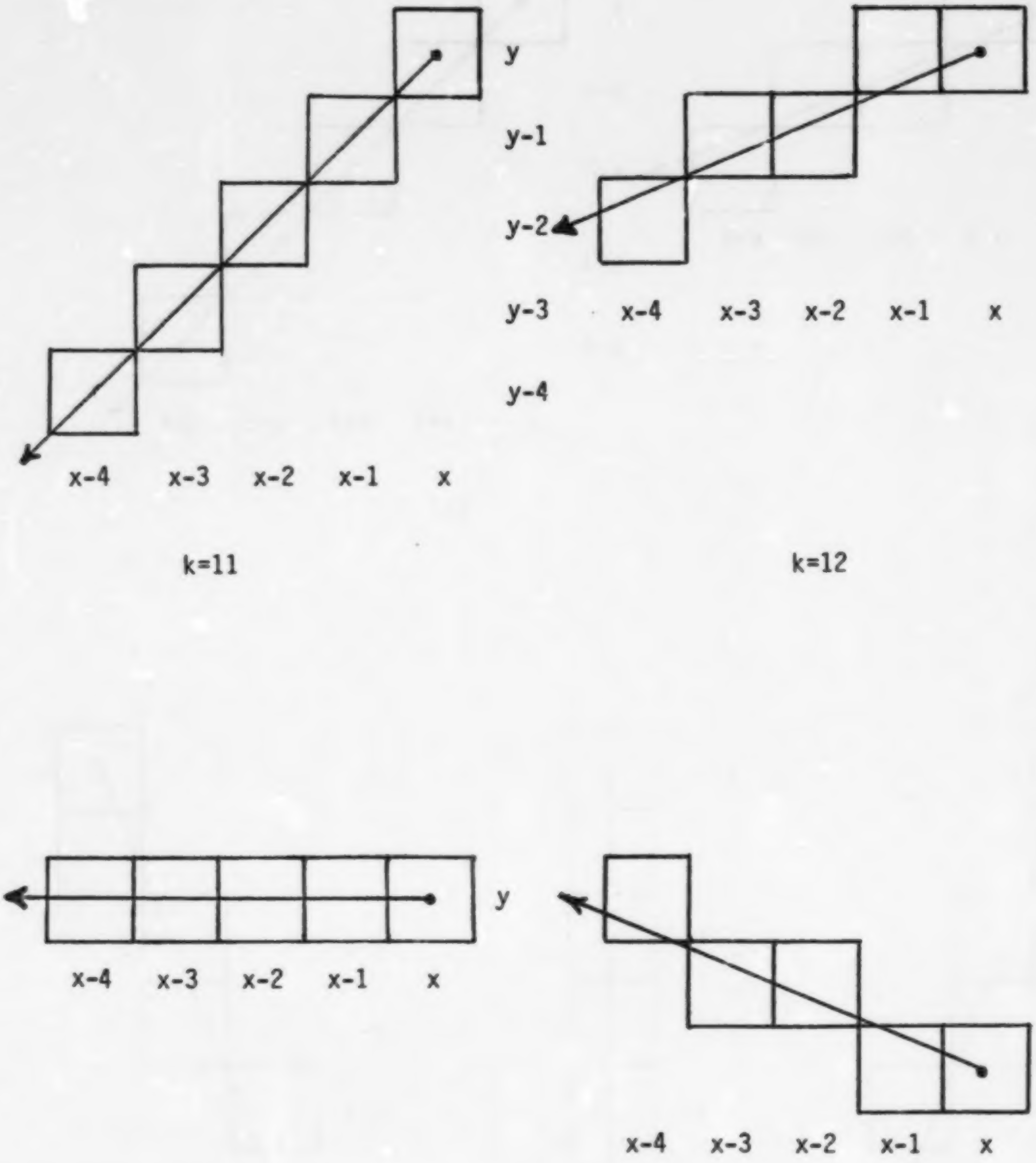
Figure 2-5 Patterns of Calculation Grid Squares Affected by an Area Source



k=6 k=7

k=8 k=9 k=10

Figure 2-5 Continued



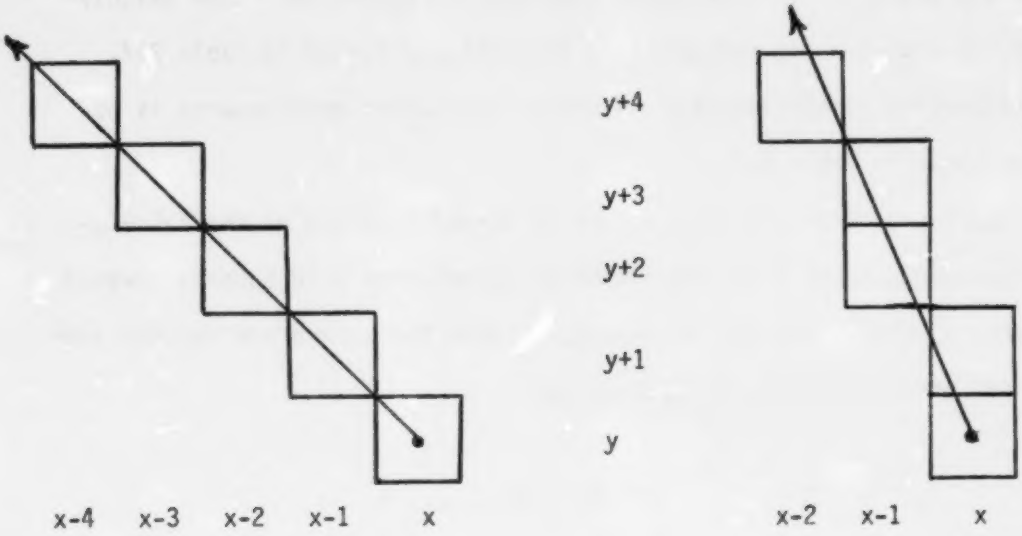
k=11

k=12

k=13

k=14

Figure 2-5 Continued



k=15

k=16

Figure 2-5 Continued

Concentrations at each receptor are determined by calculating concentrations at each receptor due to the first area source then by adding the corresponding concentrations for successive area sources. The calculations are performed by stepping through successive wind direction sectors. For each sector the pattern of affected receptors is identified, then for each affected receptor the concentration calculated by equation (16) or (17) is multiplied by the corresponding value of the meteorological joint frequency function and added to the previously recorded concentration. Some calculation grid squares are not contained in the patterns listed in Table 2-7. The concentration at the receptor in these calculation grid squares is obtained as shown in Table 2-8.

In the second case the area source is larger than one of the calculation grid squares. Let n be the number of calculation grid squares covered by the area source. Then the emissions, Q, from the source are divided into n component emission rates, Q_j defined by:

$$Q_j = Q \frac{Aj}{A} \qquad j = 1,2,\ldots\ldots, n$$

where:

A_j is the area of the source contained in the j th square and

$$A = \sum_{j=1}^{n} A_j$$

Note that $Q = \sum_{j=1}^{n} A_j$.

TABLE 2-8

Receptor Concentrations for Calculation Grid Squares Not Listed in Table 2-6

Receptor* Coordinates	Conditions	Concentrations**
(x+1, y+4)	x+1>0, y+4>0	C(x+2, y+4)
(x+2, y+3)	x+2>1, y+3>0	(C(x+1, y+3) + C(x+3, y+3))/2
	x+2=1, y+3>0	C(x+3, y+3)
(x+3, y+2)	x+2≥0, y+1>0	(C(x+3, y+3) + C(x+3, y+1))/2
	x+2≥0, y+1=0	C(x+3, y+3)
(x+4, y+1)	x+4>0, y+1>0	C(x+4, y+2)
(x+1, y-4)	x+1>0, y-4>0	C(x+2, y-4)
(x+2, y-3)	x+2>1, y-3>0	(C(x+1, y-3) + C(x+3, y-3))/2
	x+2=1, y-3>0	C(x+3, y-3)
(x+3, y-2)	x+2≥0, y-3>0	(C(x+3, y-1) + C(x+3, y-3))/2
	x+2≥0, y-3=0	C(x+3, y-1)
(x+4, y-1)	x+4>0, y-1>1	C(x+4, y-2)
	x+4>0, y-1=1	C(x+4, y)
(x-1, y-4)	x-1>1, y-4>0	C(x-2, y-4)
	x-1=1, y-4>0	C(x, y-4)
(x-2, y-3)	x-3>0, y-3>0	(C(x-1, y-3) + C(x-3, y-3))/2
	x-3=0, y-3>0	C(x-1, y-3)
(x-3, y-2)	x-3>0, y-2>1	(C(x-3, y-3) + C(x-3, y-1))/2
	x-3>0, y-2=1	C(x-3, y-1)
(x-4, y-1)	x-4=1, y-1=1	C(x-4, y)
	x-4>0, y-1>1	C(x-4, y-2)
(x-1, y+4)	x-1>0, y+4>0	C(x-2, y+4)
	x-1=1, y+4>0	C(x, y+4)
(x-2, y+3)	x-2>1, y+3>0	(C(x-1, y+3) + C(x-3, y+3))/2
	x-2=1, y+3>0	C(x-1, y+3)
(x-3, y+2)	x-3>0, y+2>1	(C(x-3, y+1) + C(x-3, y+3))/2
	x-3>0, y+2=1	C(x-3, y+3)
(x-4, y+1)	x-4>0, y+1>0	C(x-4, y+2)

*For this table the coordinates of the center of the area source are (x, y)

**C(x+1, y+1) is the concentration at coordinates (x+1, y+1)

2.3 SPECIAL SOURCE APPLICATIONS

There are a number of sources that have characteristics that do not satisfy all of the assumptions used in the algorithms covered in Sections 2.1 and 2.2.

Described below are methods that allow the use of the TCM-2 to predict pollutant dispersion from two such types of sources.

2.3.1 Flares

Flares are normally elevated sources, but they do not behave exactly like point sources. If a flare is to be treated as a point source, determination of all stack parameters is not possible. Since combustion occurs at or beyond the flare tip in the atmosphere, appropriate values for stack temperature and stack velocity cannot be determined. The diameter of pipe leading to the flare tip is not a factor in determining plume rise.

In order to use the TCM-2 to predict dispersion from flares, the point source algorithm is used with arbitrary values assigned for the stack velocity and stack temperature. At present the Texas Air Control Board uses a stack velocity of 20 m/s and a stack temperature of 1000°C. Then the effective stack diameter is determined by

$$D = \sqrt{10^{-6} q_n}$$

where:

$$q_n = q(1 - 0.048\sqrt{MW})$$

and

q is the gross heat release in cal/sec

MW is the weighted (by volume) average molecular weight of the mixture being burned.

The derivation of the value for D is shown in Appendix C. Note that q_n accounts for heat loss due to radiation. The value used was determined by Tan [12].

2.3.2 Small, Strong Area Sources

For the area source algorithm described in Section 2.2, the following assumptions are made: the source emission rate is uniform throughout the source, the emission rate is small, and the source covers a large area which is at least as large as one of the grid squares. Examples of area sources that meet these criteria are: parking lots, roads in a large area, lagoons, and residential space heating in a large area. The algorithm does not properly describe the dispersion of small sized area sources with moderate or high pollutant emission rates. Examples of these sources are: rock crushers, transfer points for conveyors, screening operations, and small storage piles. Emissions from these sources behave much like those from a point source, but there are no identifiable stack parameters. The best way to use the TCM-2 to predict pollutant dispersion from such sources is to treat the source as a point source. Arbitrary values are used for stack velocity, stack diameter, and stack temperature. These parameters determine plume rise, which is negligible for such sources. Values used by the Texas Air Control Board to produce zero plume rise are: stack velocity 0.0 m/s, stack diameter 1 m, and stack temperature 0°C. The elevation of a point of pollutant release above ground is used for the stack height. A sample TCM-2 program run for a small, strong area source using the method described above is shown in Appendix D. Results obtained with this method can be compared to those obtained with the area source algorithm as shown in Appendix E.

2.4 RECEPTOR ARRAY

2.4.1 Description of Receptor Grid

The TCM-2 calculates pollutant concentrations at each receptor in the rectilinear receptor array defined by the user. A maximum of 2500 receptors may be used with a maximum number of 50 rows and 50 columns. The spacing between each row and column is uniform and is defined by the user. Receptors are located on the intersections of grid rows and columns. The grid spacing, number of rows, number of columns, and coordinates of the receptor at the southwest corner of the grid are used to define the grid. Point and area sources do not necessarily need to be located within the grid boundaries.

If area sources are included in the source inventory, the grid spacing should be selected so that the smallest area source is the same size as a grid square. For computations involving area sources, a calculation grid is defined with grid squares the same size as receptor grid squares, but with a receptor located in the center of each calculation grid square. For details, see Section 2.2.2 and Figure 2-4.

2.5 LEAST SQUARE CALIBRATION ALGORITHM

The TCM-2 has an optional least squares calibration routine. This curve fit procedure is automatically initiated when no calibration values are input to the program run. The user can input measurements for one or two pollutants taken at up to 100 points. Inputs are measured concentrations and coordinates for each monitoring site. The TCM-2 uses subroutine REGAN to determine a least squares fit between the measured concentrations and the predicted concentrations at each monitoring site. REGAN calculates the least squares coefficients, the correlation coefficient, and the standard error for the curve fit. These least squares coefficients are then used to calculate the concentrations for the calibrated array map.

The formulas used in subroutine REGAN for the least squares curve fit are:

$$\hat{y} = a + bx$$

where:

$\hat{y}$ is the calibrated concentration

x is the predicted concentration

a and b are defined below

$$a = \frac{(\Sigma y)(\Sigma x^2) - (\Sigma x)(\Sigma xy)}{N(\Sigma x^2) - (\Sigma x^2)}$$

$$b = \frac{N(\Sigma xy) - (\Sigma x)(\Sigma y)}{N(\Sigma x^2) - (\Sigma x)^2}$$

where:

N is the number of monitoring sites

y is the measured concentration

x is the predicted concentration

The coefficient of correlation, r, is defined as

$$r = \sqrt{\frac{\Sigma(\hat{y}-\bar{y})^2}{\Sigma(y-\bar{y})^2}}$$

where $\bar{y}$ is the mean of the measured concentrations.

The standard error of estimate is

$$S = \sqrt{\frac{\Sigma(y-\hat{y})^2}{N}} = \sqrt{\frac{(y-\bar{y})^2}{N}(1-r^2)}$$

The coefficient of correlation indicates how closely the derived line fits the data. A perfect fit of a line to the data would give an r value of 1. The standard error of estimate is analogous to the standard deviation used for normal distributions.

The data input for the calibration should be carefully screened to make sure that all measurements are representative. One should be careful to properly weight or discard data from monitoring sites that are poorly located or do not accurately measure the pollutants of interest. Due to the nature of the least squares curve fit, data from periods that yield high concentrations will have a greater influence on the curve fit than data from periods with low concentrations.

2.6 TCM-2 LIMITATIONS

Some limitations associated with assumptions made in various parts of the TCM-2 are discussed below. These limitations should be considered when comparing the pollutant concentrations predicted by the TCM-2 with measured concentrations.

2.6.1 Steady State Assumption

Steady state conditions are assumed when the Gaussian dispersion equation is used. Concentration predictions are not as accurate when source or atmospheric behavior does not follow these steady state assumptions. Various aspects of these assumptions are discussed in detail.

1. Source emission rates for use in the TCM-2 are based upon mean emission rates. But short term emission rates may fluctuate, so pollutant concentrations downwind of the source will also exhibit corresponding fluctuations. These fluctuations can be large if the source is intermittent, such as a flare that functions only for a few days each year. These fluctuations are not included in the TCM-2.

2. A homogeneous horizontal wind field is assumed, i.e., for discrete periods of time, there is one average wind speed and a constant wind direction. Furthermore, one weighted average wind speed is determined for use with each atmospheric stability class. The wind direction is defined as being the

central wind direction for the wind direction sector. In actuality, the horizontal wind speed and wind direction will vary over a short time period. TCM-2 calculations are most sensitive to these fluctuations close to the source. These horizontal wind fluctuations may cause the TCM-2 to overpredict pollutant concentrations in certain locations.

3. Wind direction and wind speed will change with an increase in height. The TCM-2 calculates the change in wind speed with height. The same algorithm is used for all locations, but the amount of wind speed change can vary with location based in part upon the roughness of the terrain. No provision has been made to account for wind direction change due to wind shear. The effects of these changes will be most pronounced when effective stack heights are high and receptors are very distant from the source. Complex (rough) terrain can also affect wind direction and wind speed.

4. After there is a change in wind direction, remnants of the previously emitted plume may be blown back over the source and increase downwind pollutant concentrations. This is most evident shortly after frontal passage. The possibility of this addition to the downwind pollutant concentration is not accounted for in the steady state assumptions.

5. One of the steady state assumptions is that emissions from pollutants are transported to the receptor from all sources located up to 61 kilometers upwind of the receptor. It is also assumed the meteorological conditions do not change during the time it takes the plume to travel to the receptor. In most cases this is a reasonable assumption.

2.6.2 Dispersion Coefficients

The values for the dispersion coefficients used in the TCM-2 were obtained from power law curve fits to the curves of these coefficients given by Pasquill, Gifford, and Turner [3]. It is possible to obtain better fits to these curves, but for comparative purposes, the curve fits used in the CDM were used. The curves given by Pasquill, Gifford, and Turner were developed for flat to gently rolling terrain and may not accurately approximate values for complex terrain or for urban areas. Thus, in these cases TCM-2 predictions may not compare favorably with measured concentrations. The original data upon which these coefficients were based was not collected for distances in excess of one kilometer, so the curves were extrapolated for greater distances. Hence, values obtained in the extrapolated zone may not be as accurate as values for distances less than one kilometer. The curves are not defined for distances closer than 100 meters to the source. The seven Pasquill-Gifford atmospheric stability classes are used to categorize all atmospheric conditions. There are cases that may not fit well into any of these seven classes, hence dispersion for these meteorological conditions may not be adequately approximated by the TCM-2. Additionally, atmospheric stability classes E and F are considered together when making calculations for stable atmospheric conditions.

2.6.3 Meteorological Joint Frequency Function

A meteorological joint frequency function is used to describe the probability of occurrence of a given set of meteorological parameters. This function should be derived from actual meteorological data recorded over a period of at least 10 years. If the predicted concentrations are compared with measured concentrations, the user should be aware that the values for the joint frequency function and the actual values for the period over which the samples were collected may differ. Different values for the meteorological joint frequency function will yield different patterns and different levels of predicted concentrations.

2.6.4 Limited Vertical Mixing

The TCM-2 does not calculate the effect on pollutant concentrations caused by a limit to vertical mixing. Excluding this computation has very little effect on long time period average concentrations as shown below.

1. Stability Classes A and B. One characteristic of these two atmospheric stability classes is the rapid dispersion which occurs vertically in the mixing layer. These stability classes combined occur no more than 6% of the time for any location in Texas. Except close to the source, where a limit to vertical mixing has no effect, these stability classes produce the lowest concentrations. Hence, the effect of not including the analysis of the limited mixing height case is minimal.
2. Stability Class C. The value for σ_z exceeds 0.8 times the typical daytime mixing heights (the point where the limit to vertical mixing begins to affect downwind concentrations) at a distance of about 20 kilometers. At this distance downwind the change in concentration due to the limit to vertical mixing would be small.
3. Stability Class DD. The value for σ_z is 360 meters at a downwind distance of 60 kilometers. This is well below 0.8 times the typical daytime mixing heights. Thus, a limit to vertical mixing will have little, if any, effect on downwind concentrations.
4. Stability Class DN. The value for σ_z is 160 meters at a downwind distance of 60 kilometers. In Texas, frequently the nocturnal mixing height is above 200 meters ($\sigma_z = 0.8 \times 200$). Even if it were below this value, concentrations would be affected only at points far downwind of the source where concentrations are low. Thus any effect of a limit to vertical mixing will be minimal.

5. Stability Classes E and F. The value for σ_z is 112 meters at a downwind distance of 60 kilometers. As with stability class DN, the effect of a limit to vertical mixing will be minimal.

2.6.5 Downwash

The TCM-2 does not evaluate effects of downwash caused by nearby buildings or other terrain features. Downwash caused by nearby terrain and buildings can alter measured concentrations with the largest changes coming close to the stack. The TCM-2 does not account for other forms of atmospheric turbulence such as mechanical turbulence generated by buildings upwind and thermal turbulence caused by an urban heat island or other large areas of heat flux.

2.6.6 Terrain Adjustment

The TCM-2 does not make an adjustment for differences in terrain elevation between sources and/or receptors. In cases where the elevation of a receptor changes relative to that of the source or other receptors, a change in pollutant concentration can be expected. In particular, the plume could reach ground level closer to the source if the downwind receptors are elevated with respect to the source. In this case, the TCM-2 would predict lower concentrations than a model with terrain elevation adjustment.

Meteorological effects caused by the air crossing complex (rough) terrain are not accounted for in the TCM-2. In some cases, these effects can substantially alter measured pollutant concentrations and the location of affected receptors.

2.6.7 Pollutant Depletion

The TCM-2 is based upon algorithms developed for non-reactive pollutants. An option does allow one to approximate exponential pollutant decay, but this method is dependent upon an accurate estimate of the pollutant's half-life.

Extreme care should be exercised by the user when interpreting results from the TCM-2 if it is used to predict concentrations of pollutants that are subject to decay in the atmosphere or that will react with other atmospheric constituents.

It is assumed that all pollutants are reflected when the plume impinges upon the ground. This does not account for pollutants that react with or are desposited on the ground or vegetation and other items located on the surface.

Suspended particulates are assumed to behave like a gas. Thus, it is assumed that there is no particulate fall-out along the plume path. This is a valid assumption for small particles, but if large particles are present, a predictive algorithm based upon the terminal velocities of the large particles would probably yield more accurate results.

2.6.8 Area Source Algorithm

The area source algorithm used in the TCM-2 assumes that emissions are made at ground level. The derived equation becomes unmanageable if a source height is included. Most area sources emit pollutants within 10 meters of the surface, so this assumption will not drastically alter most concentration predictions. Note that the area source emission rate is not dependent upon the area of the source. It is assumed that the emissions occur uniformly over the area source, but dispersion is treated as if the emissions are released at the center of the source. Furthermore, in the TCM-2 the impact of an area source is limited to the nearest four receptors downwind of the source.

List of Symbols

A	Area of area source.
a	Least squares curve fit coefficient.
A_j	Area of area source in the jth calculation grid square.
$a(m)$	Coefficient for power law curve approximation of σ_z. Is a function of m. See equation (2).
b	Least squares curve fit coefficient.
$b(m)$	Exponent for power law curve approximation of σ_z. Is a function of m. See equation (2).
D	Stack diameter.
$D(\rho, H, m)$	Pollutant decay factor used to determine downwind concentration. See equation (14).
F	Buoyancy flux for a plume.
g	Acceleration due to gravity.
H	Effective stack height.
h	Physical stack height.
Δh	Plume rise.
Δh_{max}	Final plume rise.
$\Phi(k, \ell, m)$	Meteorological joint frequency function based upon wind direction, wind speed, and atmospheric stability class.
$\Phi(k, m)$	Meteorological joint frequency function based upon wind direction and atmospheric stability class.
k	Wind direction sector index.
$K(\rho, H, m)$	Factor used to determine downwind concentration. See equation (15).
ℓ	Wind speed class index.
m	Atmospheric stability class index.
MW	Weighted average molecular weight.
$P(m)$	Exponent used in equation (4) for adjustment of wind speed to a given height. Is a function of m.
ρ	Downwind distance from the stack.
q	Gross heat release.
Q	Source emission rate.
Q_j	Area source emission rate for jth calculation square covered by an area source.
R	Stack radius.
r	Lease squares coefficient of correlation.
T	Temperature at point source exit.

T_A	Ambient temperature.
$t_{1/2}$	Half-life.
U	Average wind speed at stack height.
$U^*(m)$	Weighted average wind speed for atmospheric stability class index m.
$U^*(H, m)$	Weighted average wind speed for stack height H and stability class index m .
U_ℓ	Central wind speed for wind speed class ℓ.
U_o	Average surface wind speed (as measured at 10 meters above the ground).
U_z	Wind speed at height z.
V	Stack exit velocity.
x	Downwind distance from the stack.
Δx	Size of receptor (calculation) grid square.
$\overline{y}$	Mean of measured concentrations.
$\hat{y}$	Predicted concentration adjusted by least squares curve fit.
z	Vertical distance from ground level.
σ_z	Standard deviation of the concentration distribution in vertical direction.
χ	Pollutant concentration.

REFERENCES

1. Christiansen, J. H. and Porter, R. A. "Ambient Air Quality Predictions with the Fast Air Quality Model", *Proceedings of the Conference in Ambient Air Quality Measurements*, Southwest Section of Air Pollution Control Association, pp. III - 34-35, 1975.

2. Busse, A. D. and Zimmermann, J. R. *User's Guide for the Climatological Dispersion Model*, U. S. Environmental Protection Agency, RTP, N.C. (EPA-R4-73-024), 1973.

3. Turner, D. B. *Workbook of Atmospheric Dispersion Estimates*, Office of Air Programs, Environmental Protection Agency, Publication No. AP-26, Revised 1970.

4. Pasquill, F. "The Estimation of the Dispersion of Windborne Material", *Meteorology Magazine* 90(1063); pp. 33-49, 1961.

5. Gifford, F. A. "Atmospheric Dispersion", *Nuclear Safety* 1 (3); pp. 56-62, 1960.

6. De Marrais, G. A. "Wind Speed Profiles at Brookhaven National Laboratory" *Journal of Applied Meteorology*, 16, pp. 181-189, 1959.

7. Briggs, G. A. *Plume Rise* AEC Critical Review Series, TID-25075, 1969.

8. Briggs, G. A. "Some Recent Analysis of Plume Rise Observation" *Proceedings of the Second International Clean Air Congress*, Washington, D.C., December 6-11, 1970, Academic Press, pp. 1029-1032, 1971.

9. Briggs, G. A. "Discussion on Chimney Plumes in Neutral and Stable Surroundings" *Atmospheric Environment*, 6, pp. 507-510, 1972.

10. Briggs, G. A. "Plume Rise Predictions" ATDL Contribution File No. 75/15, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 1975.

11. Gifford, F. A. and Hanna, S.R. "Urban Air Pollution Modeling" *Proceedings of the Second International Clean Air Act Congress*, Washington, D.C., December 6-11, 1970. Academic Press, pp. 1140-1151, 1971.

12. Tan, S. H. "Flare System Design Simplified", *Hydrocarbon Processing*, 46(1), pp. 172-176, 1967.

13. Texas Air Control Board *Users' Guide to the Texas Episodic Model*, Austin, Texas, 1979.

3. USERS' GUIDE

3.1 SUMMARY OF PROGRAM INPUTS

Input to the TCM-2 can be divided into six sections as listed below:

3.1.1 Control Paramaters (5 cards)

Control parameters remain constant throughout the run regardless of changes in meteorological parameters in different scenarios. They specify grid coordinates and spacing of the receptor grid, type of output desired, ambient temperatures for each scenario, and pollutant decay half-life.

3.1.2 Calibration Factors (4 to 16 cards)

Calibration factors for each pollutant for each scenario must be input. Pollutant labels and calibration labels for each pollutant for each scenario must be input. In addition, an area source scaling factor for each pollutant for each scenario must be input.

The input for each scenario begins with the meteorological joint frequency function. One set of cards as described in paragraphs 3.1.3 through 3.1.9 is needed for each scenario.

3.1.3 Meteorological Joint Frequency Function (97 cards)

Each of the 576 values for the meteorological joint frequency function plus a title card is input. These values must be representative of the time averaging period for the scenario.

3.1.4 Area Source Inventory

Each area source card contains the location, size, and emission rates of an area source. Emission rates should be typical for the time averaging period used for the scenario.

3.1.5 Blank Card

This blank card signals the end of the area source inventory card deck.

3.1.6 Point Source Inventory

Each point source card contains the location, stack parameters, and emission rate for a point source. Emission rates should be typical for the time averaging period used for the scenario.

3.1.7 Blank Card

This blank card signals the end of the point source inventory card deck.

3.1.8 Monitoring Site Data (0 - 100 cards)

If and only if the model predictions are to be calibrated with measured concentrations, each monitoring site data card contains the location and measured concentrations for a monitoring site. The measured concentration should be determined for the time averaging period used for the scenario.

3.1.9 Blank Card

This blank card signals the end of the monitoring site data deck. It is included only if monitoring site data cards are used.

Each parameter in each of the six input sections will now be described in detail. The TCM-2 coding forms used by the Texas Air Control Board will illustrate the format of the input data. A typical input deck of cards is illustrated in Figure 3-1.

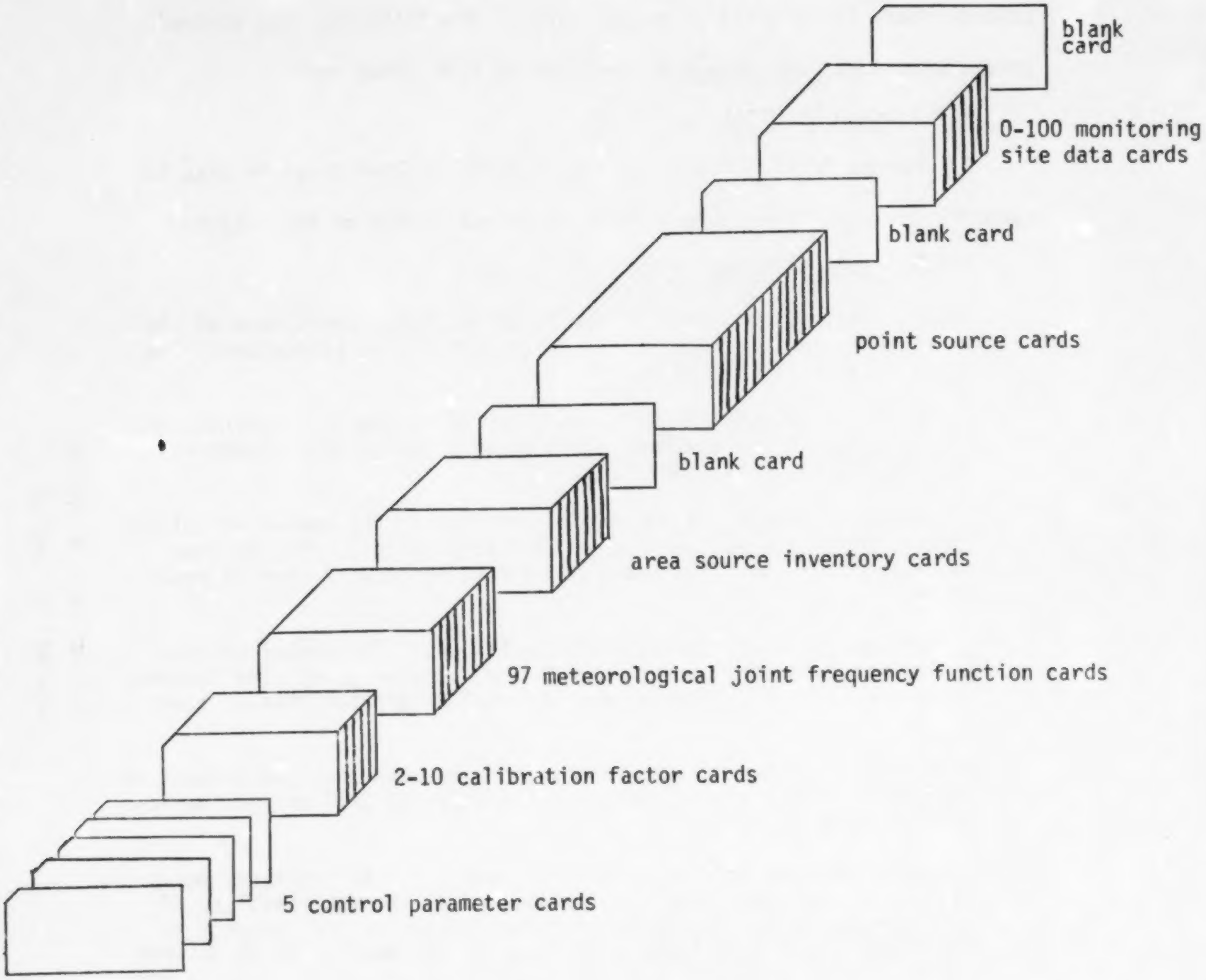

blank card
0-100 monitoring site data cards
blank card
point source cards
blank card
area source inventory cards
97 meteorological joint frequency function cards
2-10 calibration factor cards
5 control parameter cards

Figure 3-1 TCM-2 Input Deck Structure

3.2 CONTROL PARAMETERS

Figure 3-2 illustrates a TCM-2 coding form used by the Texas Air Control Board for control parameter cards. The following five control parameters cards must always be included in each TCM-2 run.

3.2.1 Card 1: TT(1) to TT(20)

TT (Format 20A4): Title. All 80 columns of Card 1 may be used to identify the run. The title is printed on every page of the output.

3.2.2 Card 2: XRSWC, YRSWC, LX, LY, GRID

XRSWC (real, columns 2-10): The X, or east-west coordinate of the receptor at the southwest grid corner. Units are kilometers. The default value is XRSWC=0.0.

YRSWC (real, columns 12-20): The Y, or north-south, coordinate of the receptor at the southwest grid corner. Units are kilometers. The default value is YRSWC=0.0.

LX (integer, columns 29-30, right-justified): The number of columns (number of receptors) per row in the receptor grid. The maximum value for LX is 50. The value of LX must be greater than or equal to one.

LY (integer, columns 39-40, right justified): The number of rows (number of receptors) per column in the receptor grid. The maximum value for LY is 50. The value of LY must be greater than or equal to one.

GRID (real, columns 43-50): The spacing between rows and columns of receptors. Units are kilometers. The value of GRID may not be less than or equal to zero.

A sample receptor grid is shown in Figure 2-4. An important point to note is that the receptors are located at the intersections of the receptor grid. Therefore, the coordinates of the receptor at the southwestern grid corner are input to the model. Point sources may be located anywhere inside or outside of the grid. Area sources should be designed to fit into an integral number of "calculation" grid squares which are the same size as the receptor grid squares, but with the receptor located in the center of the square. The coordinates of the southwestern corner of each area source will be input on a different card.

Subject of run: ______ Run requested by: ______ Date: ______

Location of study area: ______ Weather data to be used for run: station: ______ time period(s): ______

CARD 1

PROBLEM DESCRIPTION (entire card)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80

CARD 2

RECEPTOR GRID PARAMETERS

West grid boundary	South grid boundary	No. of N-S columns in grid (Max=50)	No. of E-W rows in grid (Max=50)	Spacing between rows and columns (km)
1–10	11–20	29–30	39–40	43–50
(km)	(km)	(right-justify)	(right-justify)	

CARD 3

CONTROL PARAMETERS

NUMBER OF SCENARIOS
A=Number of scenarios

POLLUTANTS-USED INDEX
B=1: 1st pollutant only
B=2: 2nd pollutant only
B=3: 1st & 2nd pollutants

PLUME RISE INDEX
C=0: Rising stage of plume used
C=1: Only final plume rise used

CONCENTRATION LIST OPTIONS
D=0: No list printed
D=1: List Printed

CONCENTRATION MAP OPTIONS
E=0: No maps printed
E=1: Maps of uncalibrated and calibrated concentrations printed
E=2: Only maps of uncalibrated concentrations printed
E=3: Only maps of calibrated concentrations printed

CULPABILITY LIST OPTIONS
F=0: No culpability list
F=1: Culpability list printed for 1st pollutant
F=2: Culpability list printed for 2nd pollutant

PUNCHED CARD OUTPUT OPTIONS
G=0: No cards punched
G=1: Cards punched

GRID PUNCH INTERVAL
H=1: Every row and column punched
H=N: Every Nth row and column punched

MET JOINT FREQ FCN INPUT OPTION
I=0: Read met data from disk file
I=1: Read met data from cards

PT SOURCE INPUT OPTION
J=0: Read Pt source data from disk file
J=1: Read Pt source data from cards

URBAN DISPERSION OPTION
K=0: Rural dispersion used
K=1: Urban dispersion used

PT SOURCE INPUT UNIT OPTION
L=1: Pt source parameters in metric units
L=2: Pt source parameters in English units
L=3: Pt source parameters in English and metric units

MAXIMUM CONCENTRATION OPTIONS
M=0: Maxima not printed
M=1: Maximum concentrations for each scenario printed

A	B	C	D	E	F	G	H	I	J	K	L	M
2	4	6	8	10	12	14	16	18	20	22	24	26

Reproduced from best available copy.

Figure 3-2 Control Parameters Coding Form

3.2.3 Card 3: NRUNS, NPOL, NPRISE, NLIST, NARRAY, NCSOPT, NPUNCH, INTPUN, INWX, INPTSC, IURBAN, NSRCOP, NMAX

A. NRUNS (integer, column 2): Number of scenarios. The value of NRUNS determines the number of sets of meteorological joint frequency functions and area and point source emission inventories that the TCM-2 will attempt to read. NRUNS may vary from one to five.

B. NPOL (integer, column 4): Pollutants-used index. The user may choose to model two pollutants during a single run; or only the first pollutant; or only the second pollutant. If the control strategy option is used, only one pollutant may be used.

NPOL = 1	First pollutant only is used.
NPOL = 2	Second pollutant only is used.
NPOL = 3	First and second pollutants are used.

C. NPRISE (integer, column 6): Plume rise index. The TCM-2 normally uses the rising stage of plume rise for calculations when appropriate. If the user wishes, the rising stage of plume rise will be disregarded and only the final plume rise will be used.

NPRISE = 0	Rising stage of plume rise will be used when appropriate.
NPRISE = 1	Only final plume rise will be used.

D. NLIST (integer, column 8): Concentration list output option. This output option provides the user with a list of the calculated concentrations at each receptor in the grid, one column of the grid per page. The default value is NLIST=0.

NLIST = 0	No list is printed.
NLIST = 1	Concentration list is printed.

E. NARRAY (integer, column 10): Concentration array output option. This option provides a printout of the concentrations across the receptor grid in the form of a spatial array, requiring one, two, or four pages to display the entire grid. Each page can display concentrations for up to 25 grid columns and 25 grid rows. The default value is NARRAY=0.

NARRAY = 0	No array maps are printed.
NARRAY = 1	Maps of both uncalibrated and calibrated concentrations are printed.
NARRAY = 2	Maps of uncalibrated concentrations only are printed.
NARRAY = 3	Maps of calibrated concentrations only are printed.

F. NCSOPT (integer, column 12): Control strategy option. When this option is used the program prints a culpability list of the five point sources which contribute the most to the total concentration for each receptor. The top five contributors to each receptor are identified by a point source sequence number. In addition, the percent of the total concentration contributed by each of the five point sources is printed. The total concentration at the receptor is also printed for reference.

The control strategy option is in addition to any other printed output requested; it does not replace any other output option.

Due to limitations on computer core storage space, this option may be used for one pollutant only and with a receptor grid of no more than 25 columns and 25 rows.

NCSOPT = 0	No culpability list is produced.
NCSOPT = 1	The control strategy option is on, and a culpability list is produced for the first pollutant.
NCSOPT = 2	The control strategy option is on, and a culpability list is produced for the second pollutant.

G. NPUNCH (integer, column 14): Punched card output option. Concentration and receptor coordinates are punched onto cards, one receptor per card, for input to a contour plotting routine. The default value is NPUNCH=0.

NPUNCH = 0	No cards are punched.
NPUNCH = 1	The card punch option is turned on. Up to 10,000 cards may be punched.

H. INTPUN (integer, column 16): Punch interval option. If punched card output is requested, INTPUN provides a way to limit the number of receptors from the grid that are to be punched. This feature is designed so that if the value for INTPUN is n, then every nth receptor in each row and column is punched onto a card. Thus, if INTPUN=2, one fourth of the receptors will be punched; if INTPUN=5, one twenty-fifth, etc. This option is included to permit contour plots to be generated without punching an unmanageable number of cards. Note that for a 50 x 50 grid with INTPUN=1, 2500 cards will be punched for each scenario. The default value is INTPUN=1.

INTPUN = 1	Every receptor in each row and column is punched onto a card (if NPUNCH=1).
INTPUN = 2	Every second receptor in each row and column is punched onto a card.
INTPUN = n	Every nth receptor in each row and column is punched onto a card.

I. INWX (integer, Column 18): Meteorological joint frequency function data read option. This option allows the user to input the meteorological joint frequency function values from a card deck or from a disk file. The default value is INWX=0.

INWX = 0	Meteorological joint frequency function is input from a disk file specified by the user in his own control card set.
INWX = 1	Meteorological joint frequency function is read into the TCM-2 from cards.

J. INPTSC (integer, column 20): Point source data read option. This option allows the user to input the point source data from a card deck or from a disk file. The default value is INPTSC=0.

INPTSC = 0	Point source data is input from a disk file specified by the user in his own control card set.
INPTSC = 1	Point source data is read into the TCM-2 from cards.

K. IURBAN (integer, column 22): Urban dispersion option. The TCM-2 normally uses rural dispersion for calculations. If the user wishes, urban dispersion may be simulated. If this option is used for area source calculations, the atmospheric stability class index will be decreased by one for all cases except class A. For point source calculations, all occurences of E and F (stable) atmospheric stability class will be replaced with class DN.

IURBAN = 0	Rural dispersion will be used.
IURBAN = 1	Urban dispersion will be used.

L. NSRCOP (integer, column 24): Point source input option. This input option allows point source parameters to be input in metric units, English units, or a mixture of the two. Area source parameters must be input in metric units.

NSRCOP = 1	The grid and point source parameters are input in metric units.
NSRCOP = 2	The grid and point source parameters are input in English units. It should be noted that only one pollutant may be modeled using this format.
NSRCOP = 3	The grid coordinates are input in metric units while point source parameters are input in English units.

M. NMAX (integer, column 26): Maximum concentration list option. This output option produces a list of the one receptor in the receptor grid which receives the highest concentration for each pollutant for each scenario. The receptor coordinates and the concentrations are printed.

NMAX = 0	Maximum concentration is not printed.
NMAX = 1	Maximum concentration option is used.

3.2.4 Card 4: TA(1), TA(2), TA(3), TA(4), TA(5)

TA(1), TA(2), TA(3), TA(4), TA(5) (real, columns 1-10, 11-20, 21-30, 31-40, 41-50, respectively): Ambient temperatures for runs 1, 2, 3, 4, and 5 respectively. The average ambient temperature, in degrees Celsius, over the time period for each run. The default value is 0.0 degrees Celsius.

3.2.5 Card 5: HALF(1), HALF(2)

HALF(1), HALF(2) (real, columns 1-10, 11-20 respectively): Decay half-lives in hours for the first and second pollutants. A value of 9999. hours should produce no perceptible decay.

3.3 CALIBRATION FACTORS

Figure 3-3 illustrates a TCM-2 coding form used by the Texas Air Control Board for calibration factor cards. At least one of each of the following types of calibration factor cards must always be included in each TCM-2 run.

3.3.1 Card 6: A(i,1), B(i,1), A(i,2), B(i,2)

A(i,1), A(i,2) (real, columns 1-10, 21-30 respectively): These are the zeroth-degree calibration coefficients for each pollutant for the ith run.

B(i,1), B(i,2) (real columns, 11-20, 31-40 respectively): These are the first degree calibration coefficients for each pollutant for the ith run.

Subject of run: ______________________ Run Requested by: ______________________ Date: __________

AMBIENT TEMPERATURE (deg C) for each scenario - fill in from left, as many temperatures as scenarios (value of A on card 3)

CARD 4

scenario 1 scenario 2 scenario 3 scenario 4 scenario 5

DECAY HALF-LIFE (hours) for each pollutant - fill in from left, as many half-lives as pollutants (value of B on card 3)

CARD 5

pollutant 1 pollutant 2

CALIBRATION FACTORS for each pollutant, for each scenario- in output, calibrated concentration = a + b x calculated concentration

	pollutant 1		pollutant 2		
	a	b	a	b	
CARD 6.1					scenario 1
CARD 6.2					scenario 2
CARD 6.3					scenario 3
CARD 6.4					scenario 4
CARD 6.5					scenario 5

If regression analysis of observed vs. calculated concentrations is desired for a scenario, leave appropriate card(s) 6 blank, and include receptor data cards after point source cards (and following blank card) for the scenario.

PUNCH as many '6' cards as value of A on card 3

Figure 3-3 Pollutant Calibration Coding Form

Subject of run: ______________________ Run Requested by: ______________________ Date: __________

	POL 1 IDENTIFICATION	POL 2 IDENTIFICATION
CARD 7		

	POL 1 CALIBRATION DESCRIPTION	POL 2 CALIBRATION DESCRIPTION	
CARD 8.1			scenario 1
CARD 8.2			scenario 2
CARD 8.3			scenario 3
CARD 8.4			scenario 4
CARD 8.5			scenario 5

PUNCH as many '8' cards as value of A on card 3

AREA SOURCE EMISSION SCALING FACTORS for each pollutant, for each scenario - all area source emission rates are multiplied by appropriate ASCALE value for pollutant and scenario.

	ASCALE pollutant 1	ASCALE pollutant 2	
CARD 9.1			scenario 1
CARD 9.2			scenario 2
CARD 9.3			scenario 3
CARD 9.4			scenario 4
CARD 9.5			scenario 5

PUNCH as many '9' cards as value of A on card 3

Figure 3-3 Continued

A and B are used to calculate the calibrated concentrations of each pollutant according to the formula:

$$X_{cal} = A + B\,X$$

where X_{cal} and X are the calibrated and uncalibrated concentrations respectively. The default values are A=B=0.0. Both calibrated and uncalibrated concentrations may appear in all output options except the culpability list option. The calibration feature has many uses. It permits conversion of concentrations from micrograms per cubic meter to percent allowable, parts per million, etc. In addition it can be used to apply an adjustment factor derived from a model validation study. If A(i,1) and B(i,1) are zero then the least squares algorithm is automatically initiated. This algorithm, which is explained in paragraph 2.5, calculates values for A and B using least squares methods to fit predicted concentrations to the monitored concentrations input by the user.

The values for A and B input on card 6 are used for run 1. Additional cards must be used to input calibration coefficients for additional runs, one card for each run.

3.3.2 Card 7: POLNAM(1), POLNAM(2)

POLNAM(1), POLNAM(2) (alphanumeric, columns 1-12 and 13-24, respectively): These two variables contain the labels for identifying the first and second pollutant concentrations in all of the output options. Anything may be entered into these variables since they serve only as labels. The default values of POLNAM(1) and POLNAM(2) are blank characters.

3.3.3 Card 8: CALNAM(i,1), CALNAM(i,2)

CALNAM(i,1), CALNAM(i,2) (alphanumeric, columns 1-28, 29-56, respectively): These two variables are used to describe the calibration factors for the ith run that were input on Card 6. The user may input anything to these variables since they are used as labels. The default values of CALNAM(i,1) and CALNAM(i,2) are blank characters.

The values input on the first card are used for run 1. Additional cards must be used to input calibration labels for additional runs, one card for each run.

3.3.4 Card 9: ASCALE(i,1), ASCALE(i,2)

ASCALE(i,1), ASCALE(i,2) (real, columns 1-10, 11-20 respectively): Area sources scaling factors for each pollutant for the ith run. The emission rate of every area source in run i is multiplied by ASCALE(i,1) for pollutant 1 and ASCALE(i,2) for pollutant 2. This feature is very useful in control strategy predictions, when an entire area source inventory may be scaled to reflect higher or lower future emission rates (e.g. changing traffic volume in future years) without having to generate an entirely new set of area sources. The default value is ASCALE=0.0, which will cause all area source contributions to be neglected.

The values for ASCALE input on the first card are used for run 1. Additional cards are used to input area source scaling values for additional runs, one card for each run.

3.4 METEOROLOGICAL JOINT FREQUENCY FUNCTION

The meteorological joint frequency function describes the probability of occurrence for each of 576 cases of three meteorological parameters.

The parameters are: Six atmospheric stability classes, sixteen equally sized wind direction sectors, and six wind speed classes. This function is specific for each geographical location and the time averaging period for the scenario. The values for this function are derived from meteorological observations made over a period of several years.

The weather station name and values for the meteorological joint frequency function are entered on 97 cards for input to the TCM-2. One set of cards must be input for each scenario.

3.4.1 Card 1: TN(1) to TN(20)

TN (format 20A4): Name of the weather station where meteorological data was collected for determination of the meteorological joint frequency function. All 80 columns of card 1 may be used. This data is printed above the tabular output of the meteorological joint frequency function, on each page of concentration output, and on the page of maximum concentrations.

3.4.2 Each of 96 cards: WIND(k), k=1,6

WIND(1), WIND(2), WIND(3), WIND(4), WIND(5), WIND(6) (real, columns 8-14, columns 15-21, columns 2228, columns 29-35, columns 36-42, columns 42-49, respectively): Probability that the wind speed will be in wind speed class 1, 2, 3, 4, 5, and 6, respectively.

3.4.3 Arrangement of Cards.

Card 1 Weather station name

Cards 2-17 Atmospheric stability class A. Card 2 contains the probability for a wind direction within wind sector 1, ..., Card 17 contains the probability for a wind direction within wind sector 16.

Cards 18-33 Atmospheric stability class B. Card 18 contains the probability for a wind direction within wind sector 1, ..., Card 33 contains the probability for a wind direction within wind sector 16.

Cards 34-49 Values for atmospheric stability class C.

Cards 50-65 Values for atmospheric stability class DD.

Cards 66-81 Values for atmospheric stability class DN.

Cards 82-97 Values for atmospheric stability class E and F.

In general the card number for wind sector index j and atmospheric stability class index i is 6(i-1)+j +1.

An example of a print out of a meteorological joint frequency function is shown in Appendix D.

The TCM-2 has an option to read the meteorological joint frequency function from a disk file. In this case the data in the disk file should be the same format and in the same order as on the cards used for the card input option.

3.5 AREA SOURCES INVENTORY

An example of an area and point source coding form used by the Texas Air Control Board is shown in Figure 3-4. Any number of area sources may be input to TCM-2 with one source per card.

The blank card that follows the last area source card is used as a signal to the computer that all area source data has been input.

3.5.1 Each Card: XA(i), YA(i), SIZE(i), EA(i,1), EA(i,2); where i is the sequence number of the source.

XA (real, columns 1-6): X-coordinate. XA is the X, or east-west coordinate of the southwest corner of the area source, in kilometers. The default value is XA=0.0 kilometers.

TEXAS CLIMATOLOGICAL MODEL (TCM)

AREA SOURCE AND POINT SOURCE DATA CODING FORM FOR: TEXAS EPISODIC MODEL (TEM-8) - metric input option Texas Air Control Board

*** INCLUDE DECIMAL POINT FOR ALL PARAMETERS ***

SOURCE COORDINATES		(AREA SOURCES ONLY)	POLLUTANT EMISSION RATES		(INPUT FOR POINT SOURCES ONLY)						
X (km)	Y (km)	source size (m)	pollutant 1 (gm/s)	pollutant 2 (gm/s)	HEIGHT (m)	DIAMETER (m)	VELOCITY (m/s)	TEMPERATURE (degrees C)		IDENTIFICATION	
1 2 3 4 5 6	7 8 9 10 11 12 13	14 15 16 17 18 19 20	21 22 23 24 25 26 27 28	29 30 31 32 33 34 35 36	37 38 39 40 41 42 43	44 45 46 47 48	49 50 51 52 53 54 55	56 57 58 59 60 61 62	63 64 65 66 67 68	69 70 71 72 73 74 75 76	77 78 79 80

Figure 3-4. Area and Point Source Data Coding Form - Metric Input.

YA (real, columns 7-13): Y-coordinate. YA is the Y, or north-south coordinate of the southwest corner of the area source, in kilometers. The default value is YA=0.0 kilometers.

SIZE (real, columns 14-20): Dimensions of source. SIZE is the length of a side of the square area source in meters. There is no default value of SIZE. The user must input a value for SIZE for each area source that is used.

EA(i,1) and EA(i,2) (real, columns 21-28 and 29-36 respectively): Emission rates for the first and second pollutants. EA(i,1) and EA(i,2) represent emission rates in grams per second. Caution: this is not an emission rate per unit area. If emission rates are given in terms of mass per unit area, these values should be multiplied by the area of the area source and any appropriate conversion factors to obtain an emission rate in terms of grams per second. Default values are EA=0.0 grams/second.

3.5.2 Construction of Area Source Inventories:

1. Superimpose a uniform grid on a map of the area of interest, with rows and columns of squares in the grid running east-west and north-south. The squares should be the same size as the smallest area source.

2. Fit each area source into the grid. Each area source must be square and should cover an integral number of grid squares. An example of several area sources fitted into a grid is shown in Figure 3-5. Note that it is possible to overlap area sources. One way this could be useful is in situations where a small, strong source is imbedded in a large, weak one.

3. Emissions are considered to come from the center of the area source. The emissions of the area source are equally divided among the grid squares covered by the source and then each grid square is treated as a separate area source. It is therefore possible for one area source card to generate 4, 25, 36, etc. area sources in the TCM-2. If more than one area source covers a grid square, then the emission rate of the square is the sum of the rates of the component area sources covering the square.

   Area sources located wholly or partially outside the calculation grid are permitted.

   The area source format is the same, whether NSRCOP=1, 2, or 3. Units are kilometers, meters, and grams per second regardless of grid and point source units used.

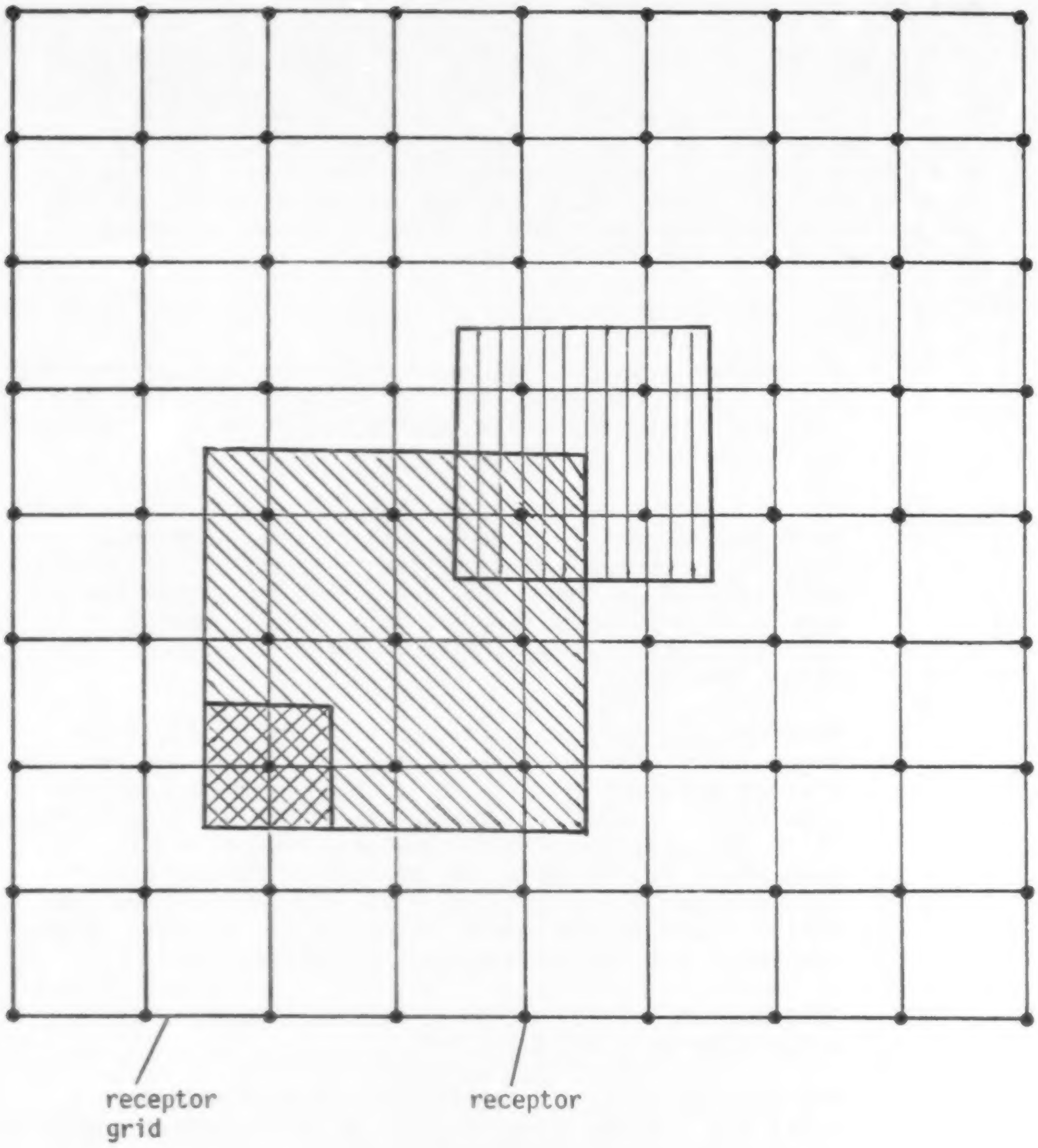


Figure 3-5 Example of Placement of Area Sources

4. Once the area source grid has been determined, a receptor is placed at the center of each square. This grid is called the calculation grid. The receptor grid that is input to the TCM-2 is the same size as the calculation grid, but is shifted so that receptors are located at the intersections of grid lines. To obtain the receptor grid, shift the calculation grid one-half of a grid spacing to the north and one-half of a grid spacing to the east. See Figure 2-4 for a diagram showing the relationship between these grids. All coordinates including those used in the area source inventory that are input to TCM-2 must be determined relative to the receptor grid.

3.6 POINT SOURCE INVENTORY

Any number of point sources may be input to the TCM-2 with one source per card.

The blank card that follows the last point source card is used as a signal to the computer that all point source data has been input.

3.6.1 Point Sources for NSRCOP=1.

An example of an area and point source coding form used by the Texas Air Control Board is shown in Figure 3-4.

Each Card: XP(i), YP(i), EP(i,1), EP(i,2), HP(i), DP(i), VP(i), TP(i), NAME(1), NAME(2); where i is the sequence number of source.

XP (real, columns 1-6): X-coordinate. XP is the X, or east-west coordinate of the point source, in kilometers. The default value is XP=0.0 kilometers.

YP (real, columns 7-13): Y-coordinate. YP is the Y, or north-south, coordinate of the point source in kilometers. The default value is 0.0 kilometers.

EP(i,1) (real, columns 21-28): Emission rate. EP(i,1) is the emission rate of pollutant-1 in grams per second. The default value is 0.0 grams per second.

EP(i,2) (real, columns 29-36): Emission rate. EP(i,2) is the emission rate of pollutant-2 in grams per second. The default value is 0.0 grams per second.

HP (real, columns 37-43): Source height. HP is the physical height of the stack in meters. The default value is HP=0.0 meters.

DP (real, columns 44-48): Source diameter. DP is the inside exit diameter of the source in meters. The default value is DP=0.0 meters.

VP (real, columns 49-55): Exit velocity. VP is the stack exit velocity in meters per second. The default value is VP=0.0 meters per second; but this value will yield zero plume rise.

TP (real, columns 56-62): Exit temperature. TP is the temperature, in degrees Celsius, of the plume as it leaves the stack. The default value is 0.0 degrees which usually results in a momentum-dominated plume rise.

NAME (alphanumeric, columns 69-76): Source identification. NAME(i,1) and NAME(i,2) constitute an eight-character field containing an identification code for each source.

NOTE: The area and point source formats and units for NSRCOP=1 are identical to those used in the EPA's Climatological Dispersion Model [2] and the Texas Air Control Board's Texas Episodic Model [13].

3.6.2 Point Sources for NSRCOP=2.

An example of an NSRCOP=2 Coding Form used by the Texas Air Control Board is shown in Figure 3-6.

Each Card: NAME(i,1), XP(i), YP(i), EP(i,1), HP(i), DP(i), VP(i), ACFM, TP(i); where i is the sequence number of sources.

NAME (alphanumeric, columns 1-4): Source identification. NAME(i,1) is a four-character field containing an identification code for each source.

XP (real, 6-15): X-coordinate. XP is the X, or east-west coordinate of the point source, in feet. The default value is 0.0 feet.

YP (real, 16-25): Y-coordinate. YP is the Y, or north-south coordinate of the point source in feet. The default value is YP=0.0 feet.

EP (real, 26-35): Emission rate. EP(i,1) is the emission rate of pollutant-1 in pounds per hour. Default value is EP(i,1)=0.0 pounds per hour. Note: in this format only one pollutant emission rate may be input for each point source.

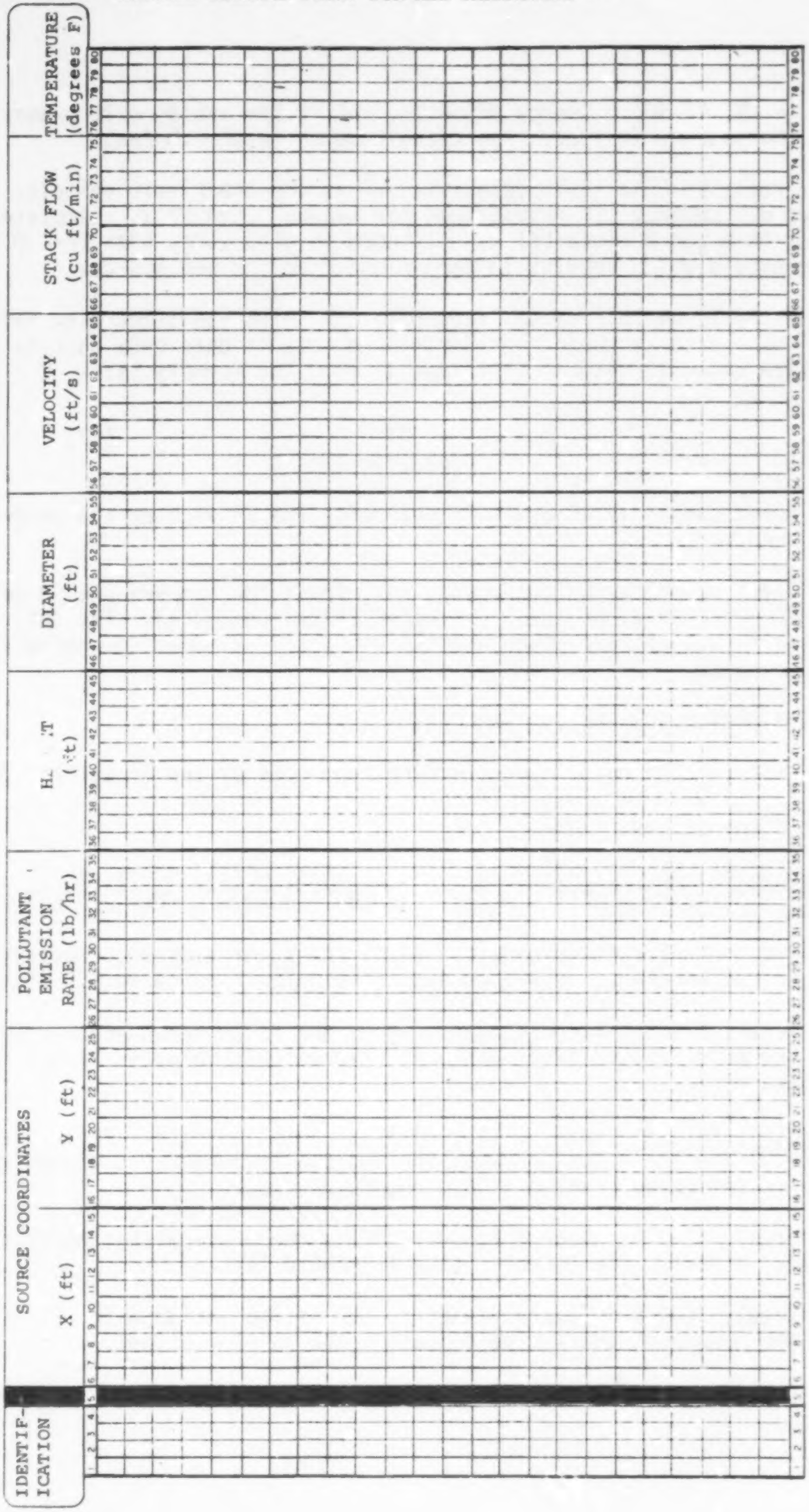
HP (real, 36-45): Source height. HP is the physical height of the stack in feet. Default value is HP=0.0 feet.

POINT SOURCE DATA CODING FORM FOR:

TEXAS CLIMATOLOGICAL MODEL (TCM)
TEXAS EPISODIC MODEL (TEM) - English input option

Texas Air Control Board

*** INCLUDE DECIMAL POINT FOR ALL PARAMETERS ***



IDENTIFICATION		SOURCE COORDINATES		POLLUTANT EMISSION RATE (lb/hr)	HEIGHT (ft)	DIAMETER (ft)	VELOCITY (ft/s)	STACK FLOW (cu ft/min)	TEMPERATURE (degrees F)
		X (ft)	Y (ft)						
1 2 3 4	5	6 7 8 9 10 11 12 13 14 15	16 17 18 19 20 21 22 23 24 25	26 27 28 29 30 31 32 33 34 35	36 37 38 39 40 41 42 43 44 45	46 47 48 49 50 51 52 53 54 55	56 57 58 59 60 61 62 63 64 65	66 67 68 69 70 71 72 73 74 75	76 77 78 79 80

Figure 3-6. Area and Point Source Data Coding Form - English Input

DP (real, 46-55): Source diameter. DP is the inside exit diameter of the source, in feet. The default value is DP=0.0 feet.

VP (real, 56-65): Exit velocity. VP is the stack exit velocity in feet per second. If VP=0.0 feet per second, then VP is calculated from ACFM and DP (see below). If ACFM is also zero, then VP=0.0 feet per second which results in zero plume rise for the source.

ACFM (real, 66-75): Stack flow rate. ACFM is the stack flow rate of the source in cubic feet per minute. It is used only to calculate exit velocity if VP is not given. The formula is:

$$VP = \frac{ACFM}{(47.1239\ (DP)^2)} \qquad (27)$$

As noted above, if VP and ACFM are zero, the VP used by the program is zero.

TP (real, 76-80): Exit temperature. TP is the temperature in degrees Fahrenheit, of the plume as it leaves the stack. The default value is 0.0 degrees which usually results in a momentum-dominated plume rise.

3.6.3 Point Sources for NSRCOP=3

An example of a point source coding form used by the Texas Air Control Board is shown in Figure 3-7.

Each Card: XP(i), YP(i), EP(i,1), EP(i,2), HP(i), DP(i), VP(i), TP(i), ACFM(i), NAME(i); where i is the sequence number of source.

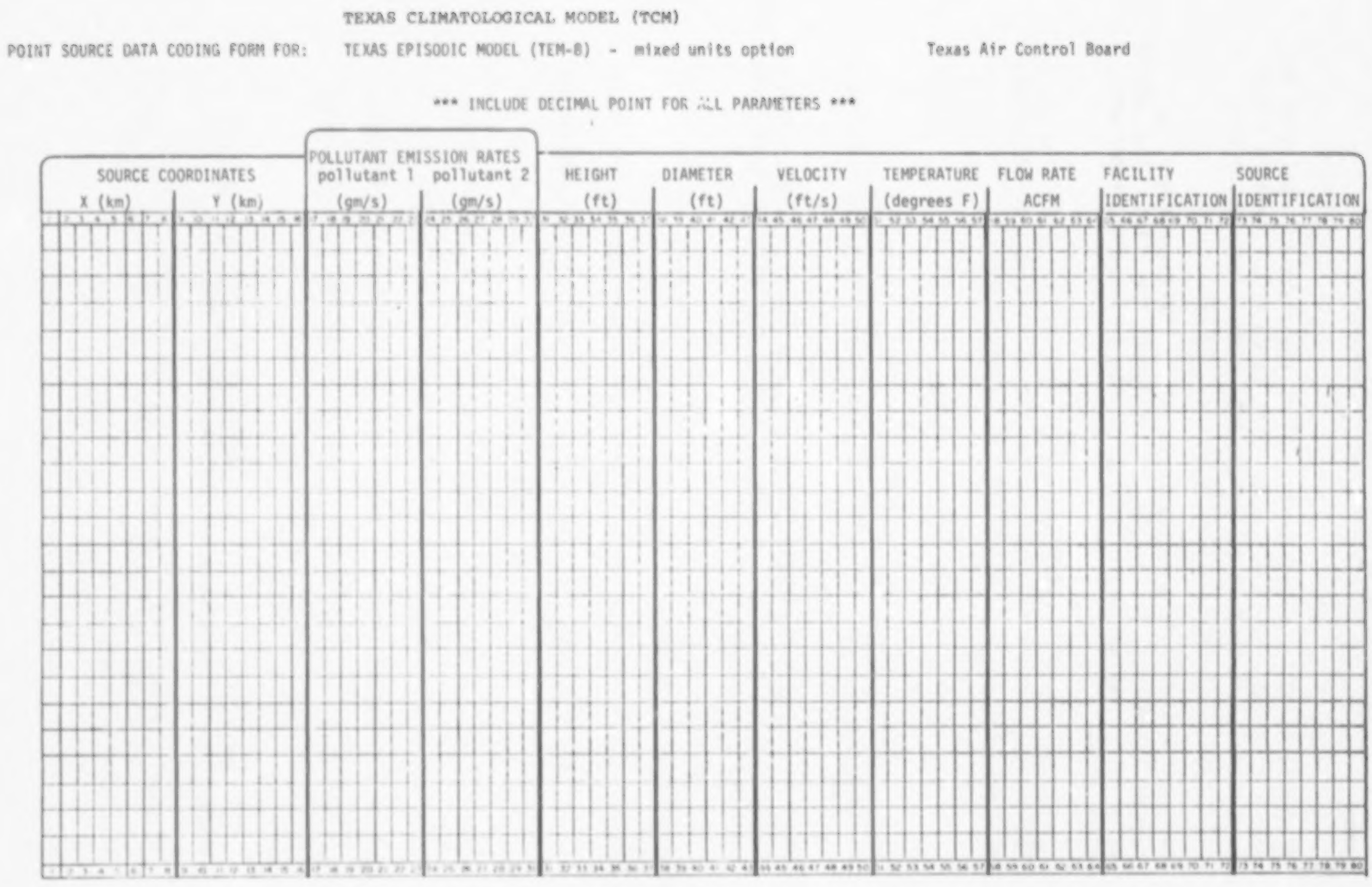
XP (real, 1-8): X-coordinate. XP is the X, or east-west coordinate of the point source in kilometers. The default value is 0.0 kilometers.

YP (real, 9-16): Y-coordinate. YP is the Y, or north-south coordinate of the point source in kilometers. The default value is YP=0.0 kilometers.

EP(i,1), EP(i,2) (real, 17-23, 24-30): Emission rate. EP(i,1) and EP(i,2) are the emission rates for the two pollutants in pounds per hour. The default value is 0.0 pounds per hour.

HP (real, 31-37): Source height. HP is the physical height of the stack in feet. The default value is HP=0.0 feet.

DP (real, 38-43): Source diameter. DP is the inside exit diameter of the source in feet. The default value is DP=0.0 feet.



TEXAS CLIMATOLOGICAL MODEL (TCM)

POINT SOURCE DATA CODING FORM FOR: TEXAS EPISODIC MODEL (TEM-8) - mixed units option

Texas Air Control Board

*** INCLUDE DECIMAL POINT FOR ALL PARAMETERS ***

SOURCE COORDINATES		POLLUTANT EMISSION RATES								
X (km)	Y (km)	pollutant 1 (gm/s)	pollutant 2 (gm/s)	HEIGHT (ft)	DIAMETER (ft)	VELOCITY (ft/s)	TEMPERATURE (degrees F)	FLOW RATE ACFM	FACILITY IDENTIFICATION	SOURCE IDENTIFICATION

Figure 3-7. Area and Point Source Data Coding Form - Mixed-Unit Input

VP (real, 44-50): Exit velocity. VP is the stack exit velocity in feet per second. If VP=0.0, then VP is calculated from ACFM and DP (see below). If ACFM is also zero, then VP=0.0 feet per second which results in zero plume rise for the source.

TP (real, 51-57): Exit temperature. TP is the temperature, in degrees Fahrenheit, of the plume as it leaves the stack. The default value is 0.0 degrees which usually results in a momentum-dominated plume rise.

ACFM (real, 58-64): Stack flow rate. ACFM is the stack flow of the source in cubic feet per minute. It is used only to calculate exit velocity if VP is not given. The formula is:

$$VP = \frac{ACFM}{(47.1239\ (DP)^2)}$$

As noted above, if VP and ACFM are zero, then VP used by the program is zero.

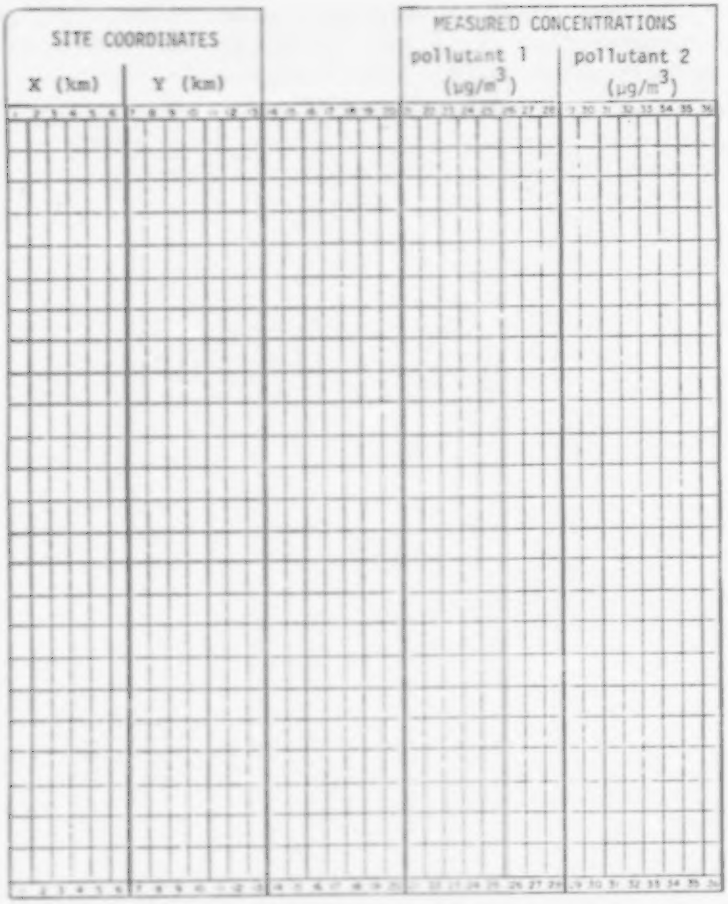
NAME (alphanumeric, columns 65-80): Source identification. This variable constitutes a 16 character field containing an identification code for each source.

3.7 MONITORING SITE DATA

An example of a monitoring site data coding form used by the Texas Air Control Board is shown in Figure 3-8. For each scenario monitoring data for up to 100 sites may be input for use in the least squares fit with predicted concentrations. Measurements for one or two pollutants may be input. The blank card that follows the last monitoring site card is used as a signal to the computer that all monitoring data has been input. This blank card is included only if monitoring site data cards are used.

3.7.1 Each of 0 to 100 cards: XR(i), YR(i), CR(i,1), CR(i,2), where i is the sequence number of the monitoring site.

XR (real, columns 1-6): X-coordinate. XR is the X, or east-west coordinate of the monitoring site, in kilometers. The default value is XR=0.0 kilometers.



SITE COORDINATES

X (km)

Y (km)

MEASURED CONCENTRATIONS

pollutant 1 ($\mu g/m^3$)

pollutant 2 ($\mu g/m^3$)

Figure 3-8 Monitoring Site Data Coding Form

YR (real, columns 7-13): Y-coordinate. YR is the Y, or north-south, coordinate of the monitoring site in kilometers. The default value is 0.0 kilometers.

CR(i,1) (real, columns 21-28): Measured concentration. CR(i,1) is the measured concentration of pollutant 1 at the monitoring site in ug/m^3. The default value is CR(i,1)=0.0 ug/m^3.

CR(i,2) (real, columns 29-36): Measured concentration. CR(i,2) is the measured concentration of pollutant 2 at the monitoring site and ug/m^3. The default value is CR(i,2)=0.0 ug/m^3.

4. TCM-2 FLOW DIAGRAMS

The Texas Climatological Model Version 2 (TCM-2) is written in Fortran IV language. At the present time the Texas Air Control Board uses a Burroughs B6810/11 computer for the TCM-2.

The TCM-2 contains a main program and eight subroutines. Table 4-1 defines the variables used in the following flow diagrams.

The main program calculates pollutant concentrations at each receptor while subroutines perform ancillary functions. Subroutine SECTOR determines the sector number and value for the meteorological joint frequency function for each source-receptor combination. Subroutine KCAL calculates the value for KPS either explicitly or by interpolation in the KPS table. If no calibration factors are input by the user, subroutine REGAN calculates the least squares calibration factors, correlation coefficient, and standard error. Subroutine ARRAY prints the array map concentrations. If a culpability list is requested, subroutine WORST determines the five highest point source contributors at each receptor. Subroutine WOROUT then prints the culpability list. Subroutine RISE calculates effective stack heights for point sources. If a list of maximum concentrations is requested, MAXOUT determines and prints the list.

The following flow diagrams briefly outline the basic programming steps used in TCM-2. The complete program is listed in Appendix G.

TABLE 4-1

List of Variables Used in the TCM-2 Flowcharts

Variable	Function
AF	An internal label for the calibration coefficient for the zeroth degree term.
BF	An internal label for the calibration coefficient for the first degree term.
DIST	Source-receptor distance.
FSH	Internal value used for linear interpolation in the KPS table.
GRID	Receptor grid spacing.
IP	Internal loop counter for number of pollutants.
IRISE	Internal parameter used to cue different sections of subroutine RISE.
IS	Internal loop counter for atmospheric stability class index.
k	Wind sector index.
LX	Number of columns in the receptor grid.
LY	Number of rows in the receptor grid.
NCSOPT	Control strategy (culpability list) option parameter.
NPOL	Number of pollutants.
NPRISE	Plume rise index.
NR	Number of monitoring sites for which data is input for model calibration.
NSH	Internal value used for linear interpolation in the KPS table.
PEAK	Distance downwind of the source at which the plume reaches its maximum height.

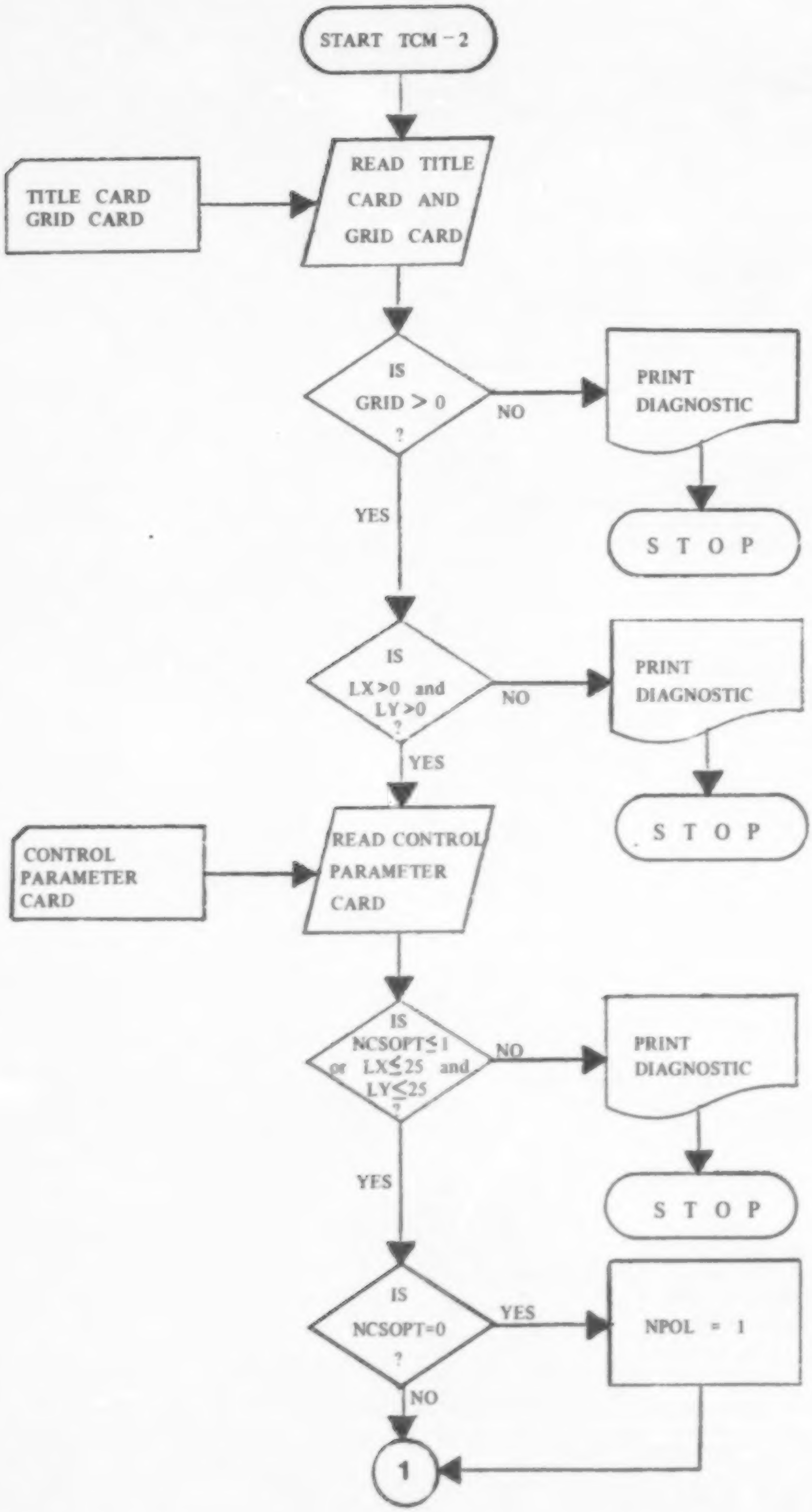


Figure 4-1 TCM-2 Program

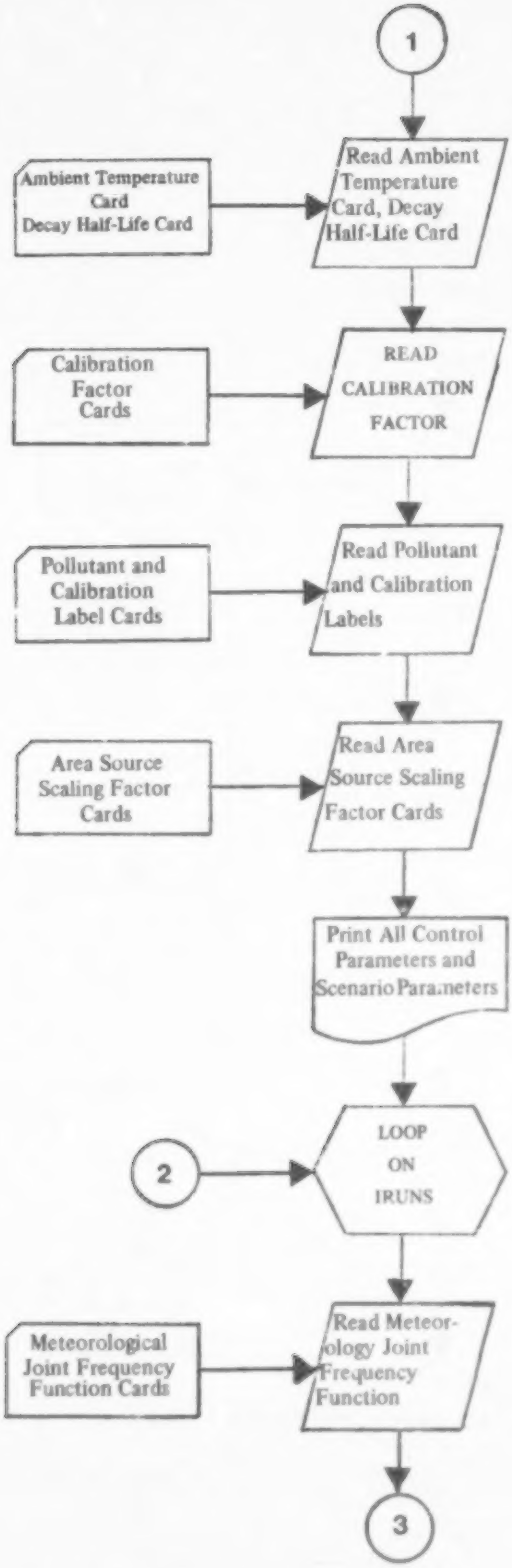

1
Ambient Temperature Card
Decay Half-Life Card
Read Ambient Temperature Card, Decay Half-Life Card
Calibration Factor Cards
READ CALIBRATION FACTOR
Pollutant and Calibration Label Cards
Read Pollutant and Calibration Labels
Area Source Scaling Factor Cards
Read Area Source Scaling Factor Cards
Print All Control Parameters and Scenario Parameters
2
LOOP ON IRUNS
Meteorological Joint Frequency Function Cards
Read Meteorology Joint Frequency Function
3

Figure 4-1 continued

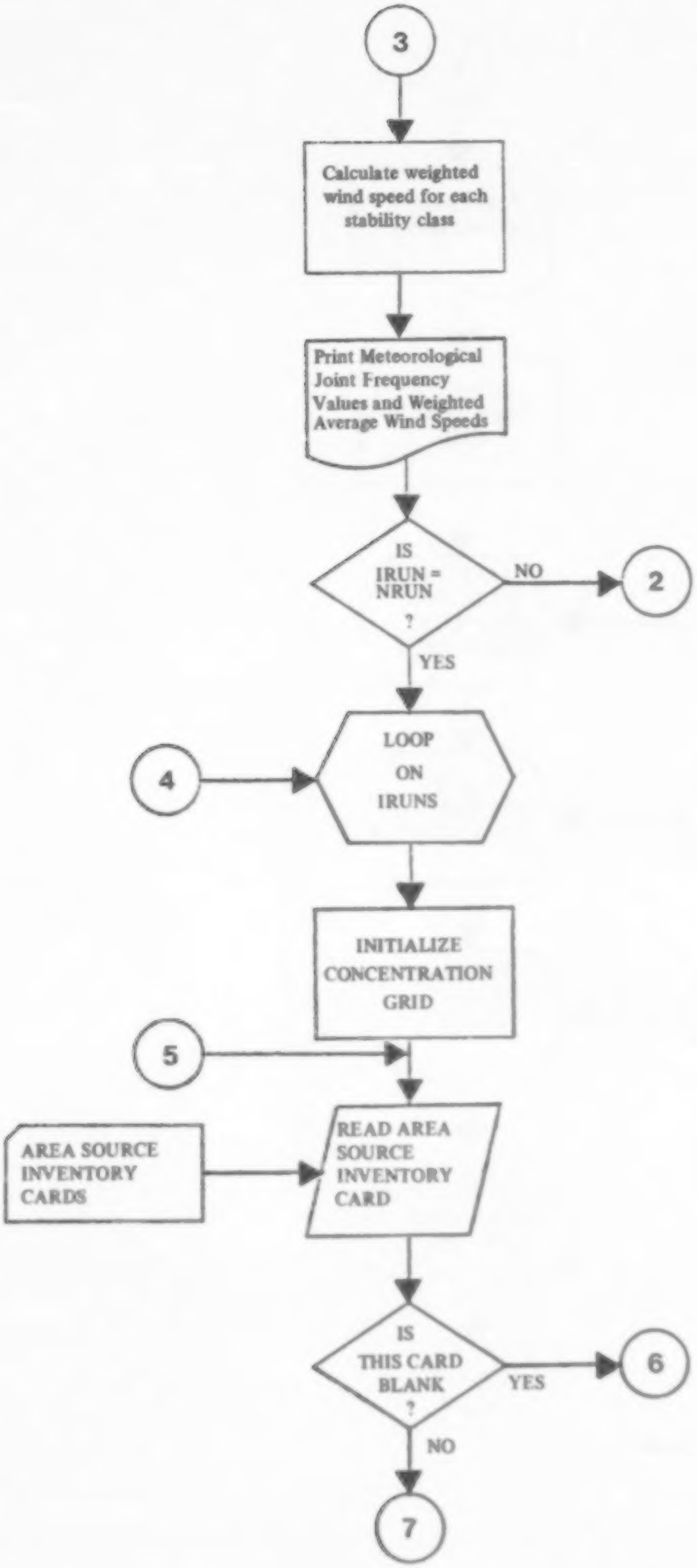

3
Calculate weighted wind speed for each stability class
Print Meteorological Joint Frequency Values and Weighted Average Wind Speeds
IS IRUN = NRUN ?
NO
2
YES
4
LOOP ON IRUNS
INITIALIZE CONCENTRATION GRID
5
AREA SOURCE INVENTORY CARDS
READ AREA SOURCE INVENTORY CARD
IS THIS CARD BLANK ?
YES
6
NO
7

Figure 4-1 continued

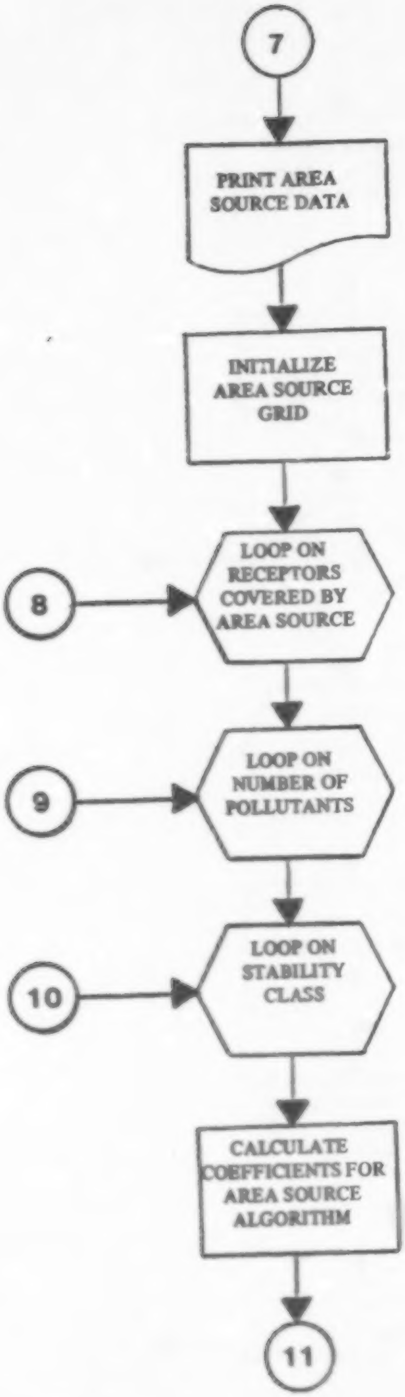

7
PRINT AREA SOURCE DATA
INITIALIZE AREA SOURCE GRID
8
LOOP ON RECEPTORS COVERED BY AREA SOURCE
9
LOOP ON NUMBER OF POLLUTANTS
10
LOOP ON STABILITY CLASS
CALCULATE COEFFICIENTS FOR AREA SOURCE ALGORITHM
11

Figure 4-1 continued

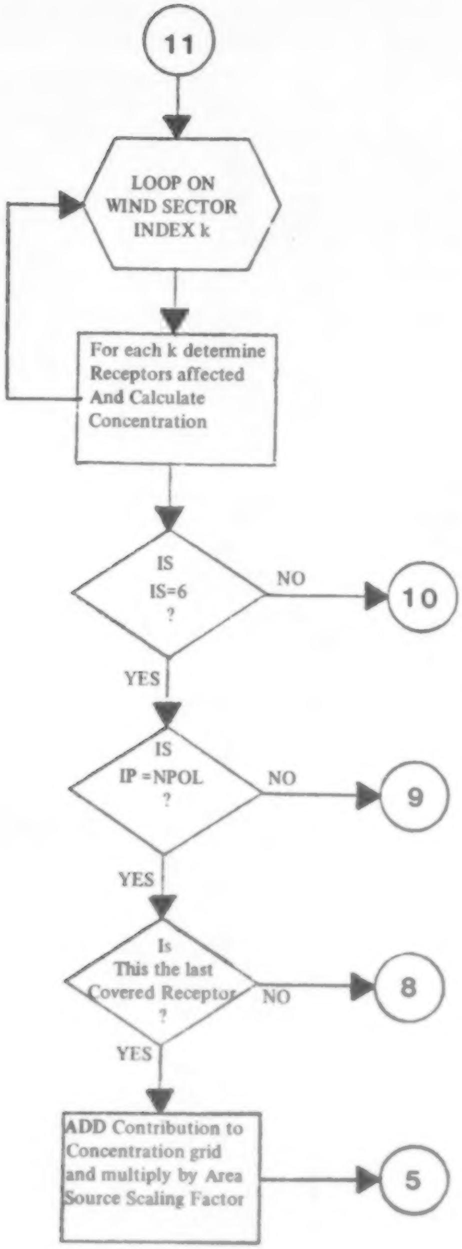

11
LOOP ON WIND SECTOR INDEX k
For each k determine Receptors affected And Calculate Concentration
IS IS=6 ?
NO
10
YES
IS IP =NPOL ?
NO
9
YES
Is This the last Covered Receptor ?
NO
8
YES
ADD Contribution to Concentration grid and multiply by Area Source Scaling Factor
5

Figure 4-1 continued

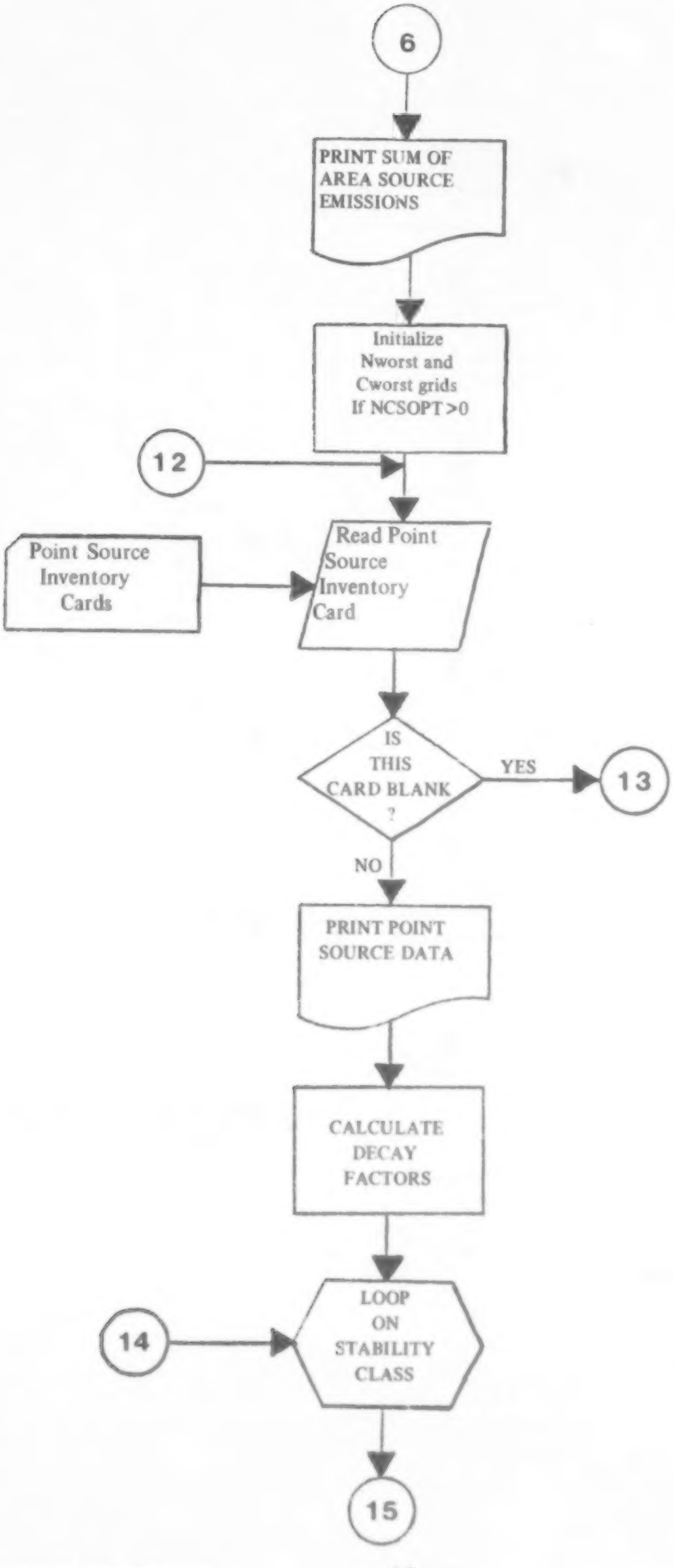

6
PRINT SUM OF AREA SOURCE EMISSIONS
Initialize Nworst and Cworst grids If NCSOPT >0
12
Point Source Inventory Cards
Read Point Source Inventory Card
IS THIS CARD BLANK ?
YES
13
NO
PRINT POINT SOURCE DATA
CALCULATE DECAY FACTORS
14
LOOP ON STABILITY CLASS
15

Figure 4-1 continued

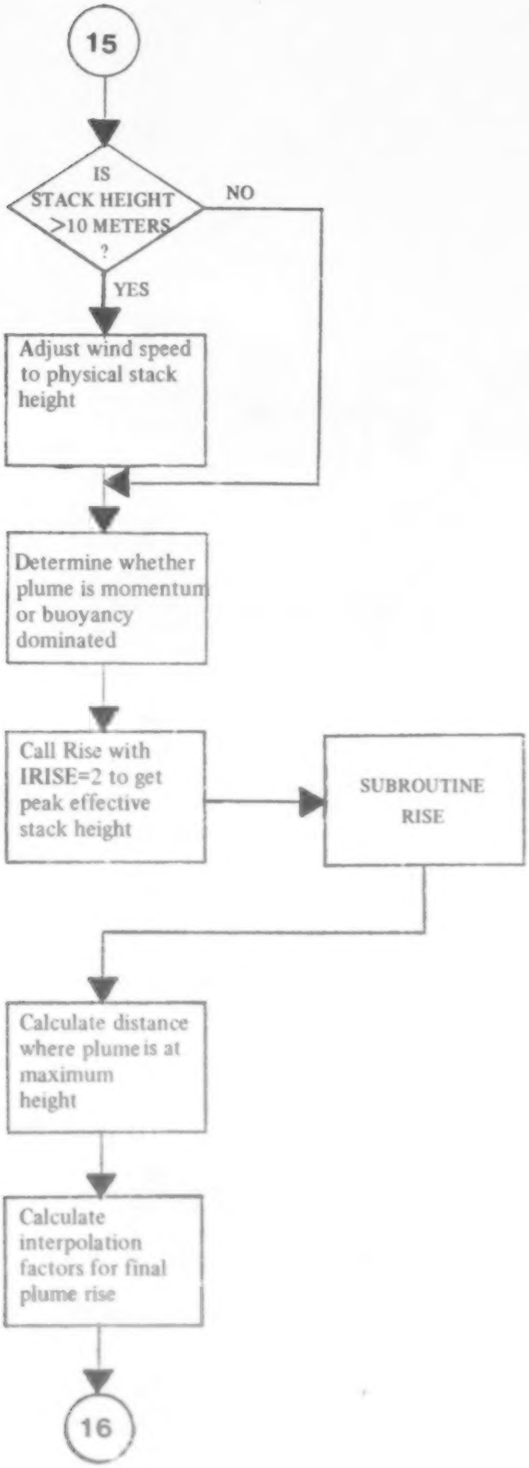

15
IS STACK HEIGHT >10 METERS ?
NO
YES
Adjust wind speed to physical stack height
Determine whether plume is momentum or buoyancy dominated
Call Rise with IRISE=2 to get peak effective stack height
SUBROUTINE RISE
Calculate distance where plume is at maximum height
Calculate interpolation factors for final plume rise
16

Figure 4-1 continued

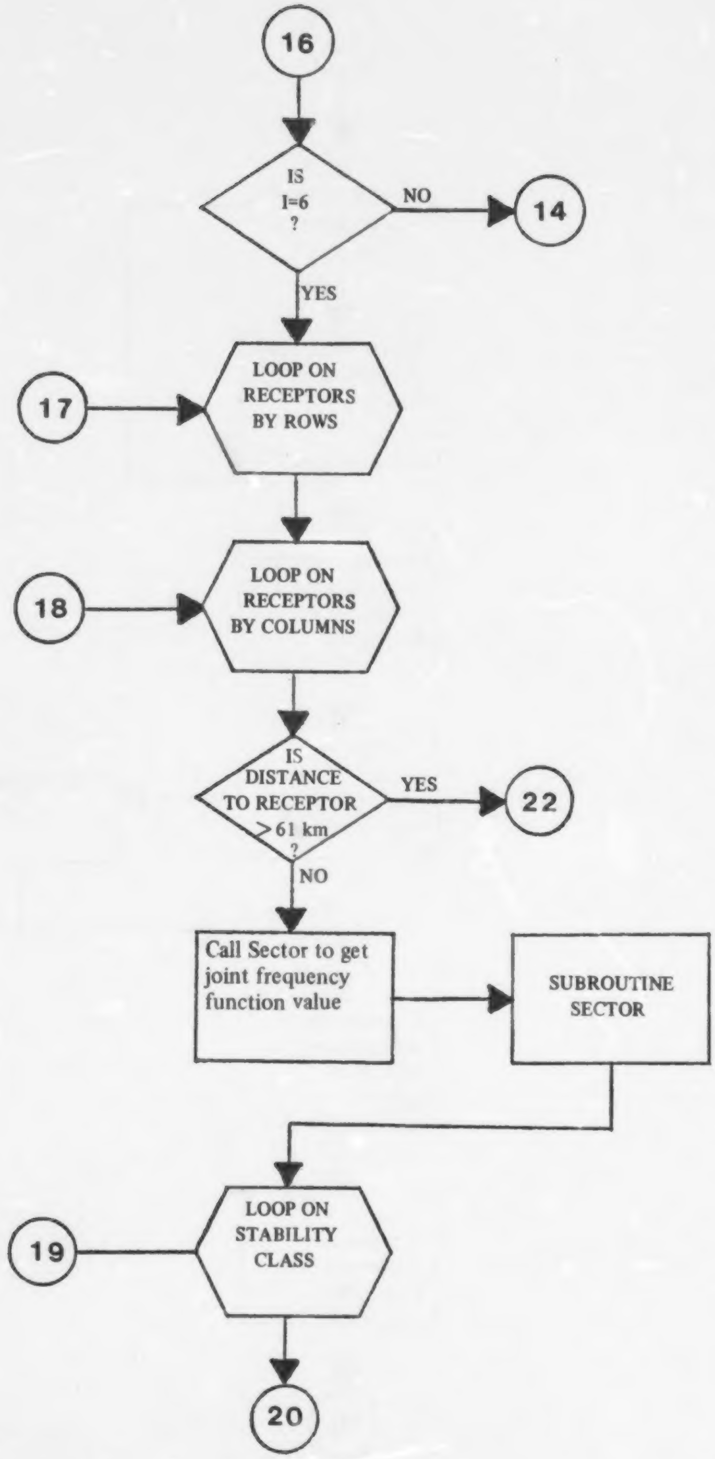


Figure 4-1 continued

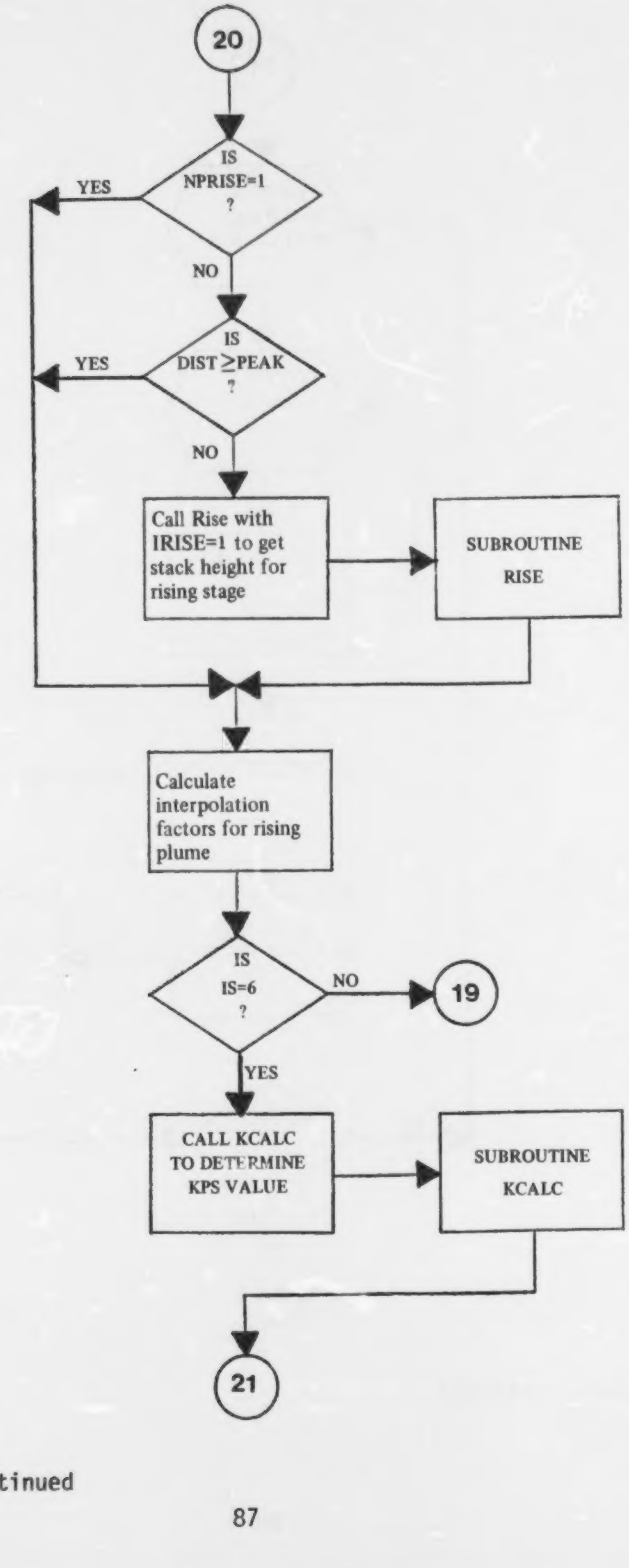

20
IS NPRISE=1 ?
YES
NO
IS DIST ≥ PEAK ?
YES
NO
Call Rise with IRISE=1 to get stack height for rising stage
SUBROUTINE RISE
Calculate interpolation factors for rising plume
IS IS=6 ?
NO
19
YES
CALL KCALC TO DETERMINE KPS VALUE
SUBROUTINE KCALC
21

Figure 4-1 continued

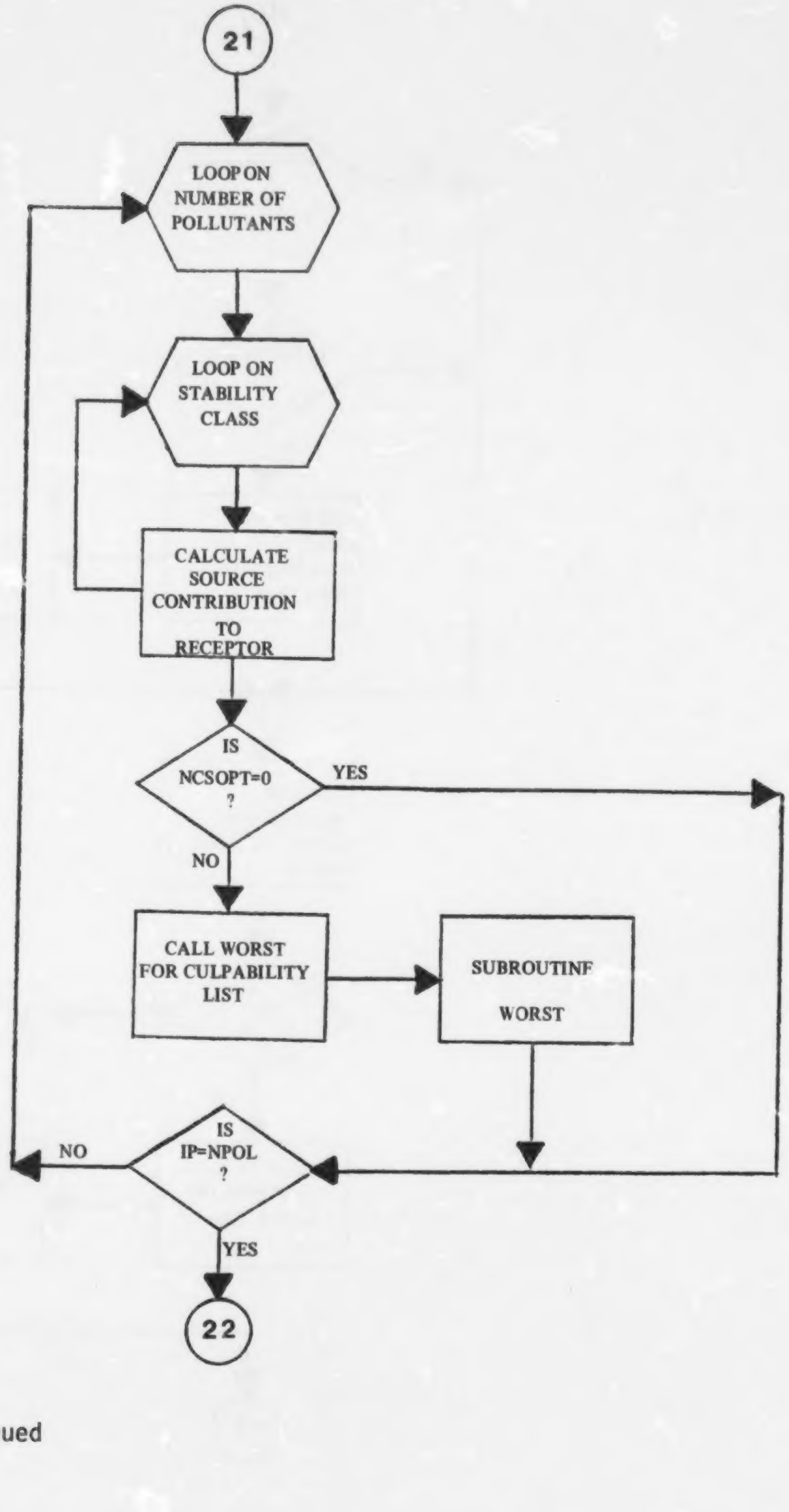

21
LOOP ON NUMBER OF POLLUTANTS
LOOP ON STABILITY CLASS
CALCULATE SOURCE CONTRIBUTION TO RECEPTOR
IS NCSOPT=0 ?
YES
NO
CALL WORST FOR CULPABILITY LIST
SUBROUTINF WORST
IS IP=NPOL ?
NO
YES
22

Figure 4-1 continued

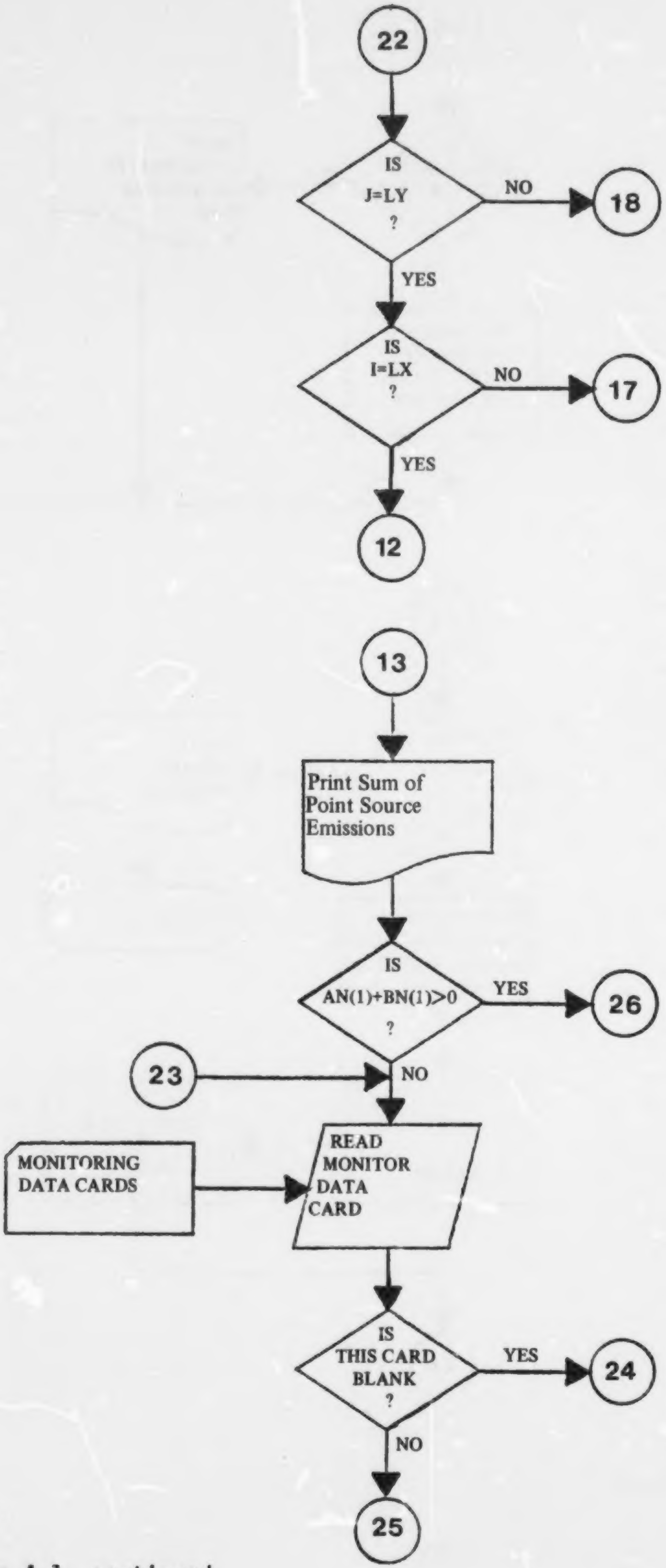


Figure 4-1 continued

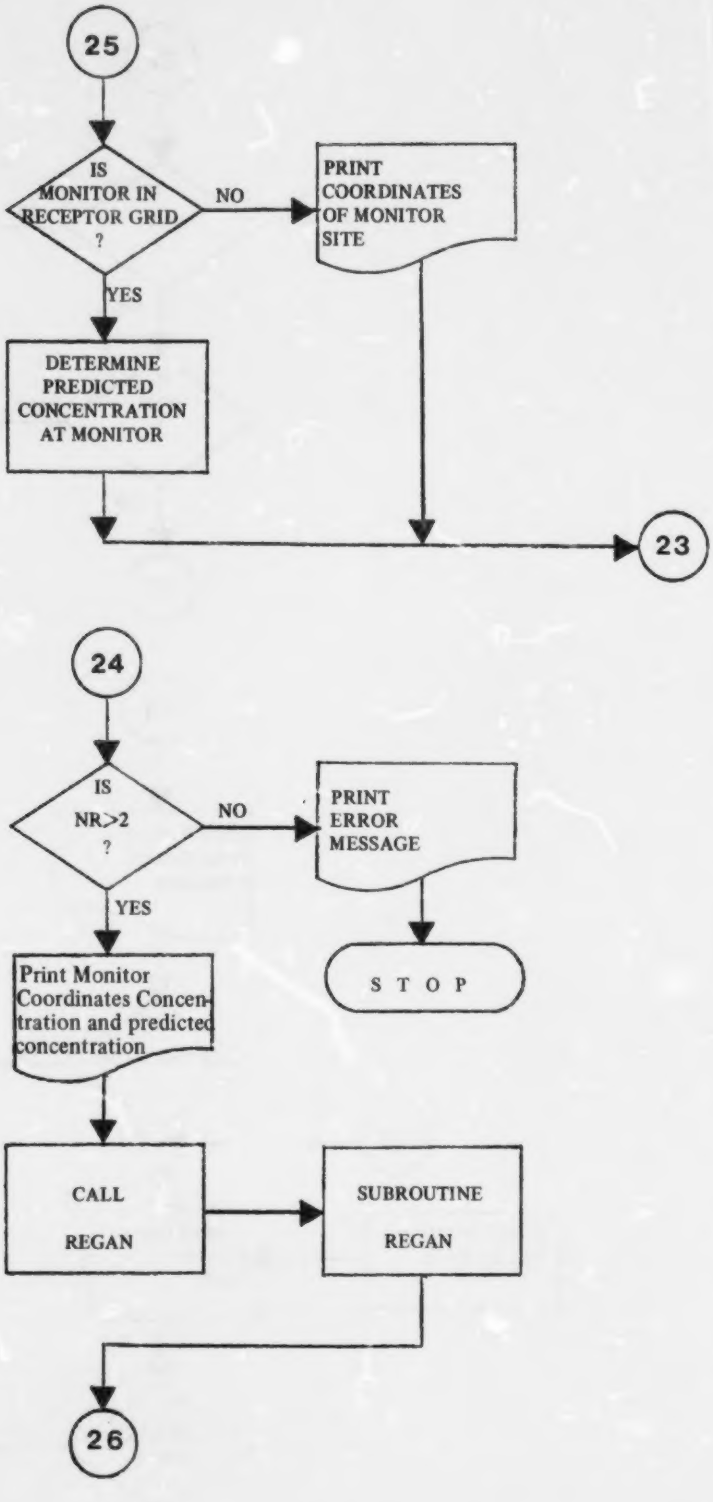

25
IS MONITOR IN RECEPTOR GRID ?
NO
PRINT COORDINATES OF MONITOR SITE
YES
DETERMINE PREDICTED CONCENTRATION AT MONITOR
23
24
IS NR>2 ?
NO
PRINT ERROR MESSAGE
STOP
YES
Print Monitor Coordinates Concentration and predicted concentration
CALL REGAN
SUBROUTINE REGAN
26

Figure 4-1 continued

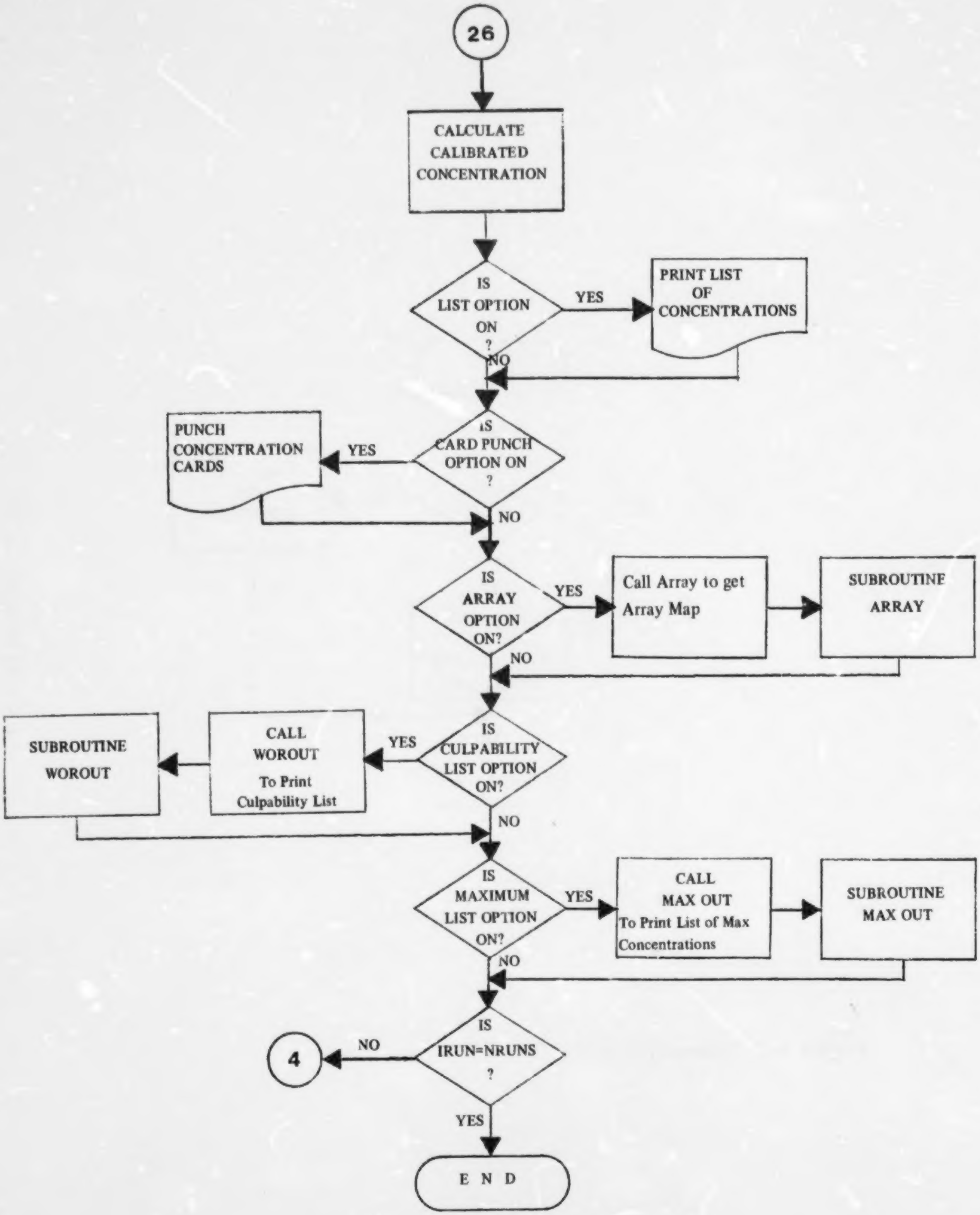

26
CALCULATE CALIBRATED CONCENTRATION
IS LIST OPTION ON ?
YES
PRINT LIST OF CONCENTRATIONS
NO
IS CARD PUNCH OPTION ON ?
YES
PUNCH CONCENTRATION CARDS
NO
IS ARRAY OPTION ON?
YES
Call Array to get Array Map
SUBROUTINE ARRAY
NO
IS CULPABILITY LIST OPTION ON?
YES
CALL WOROUT To Print Culpability List
SUBROUTINE WOROUT
NO
IS MAXIMUM LIST OPTION ON?
YES
CALL MAX OUT To Print List of Max Concentrations
SUBROUTINE MAX OUT
NO
IS IRUN=NRUNS ?
NO
4
YES
E N D

Figure 4-1 continued

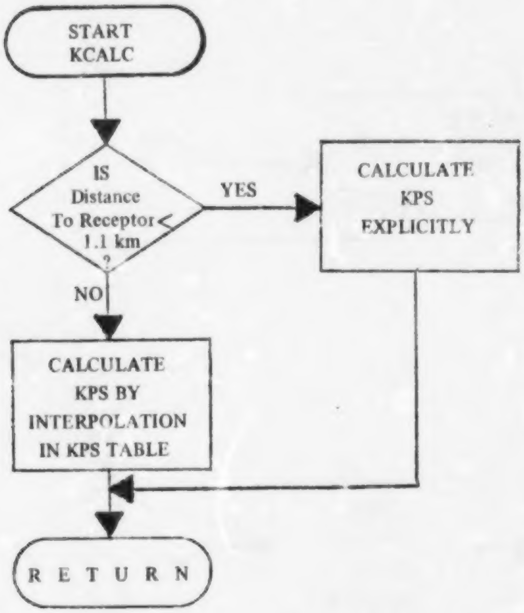


Figure 4-2 Subroutine KCALC

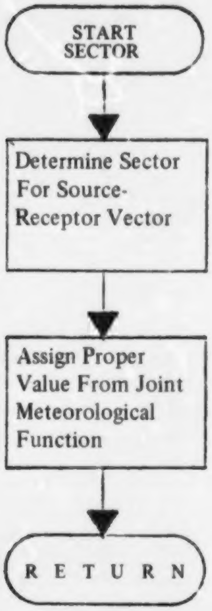

START SECTOR
Determine Sector For Source-Receptor Vector
Assign Proper Value From Joint Meteorological Function
RETURN

Figure 4-3 Subroutine SECTOR

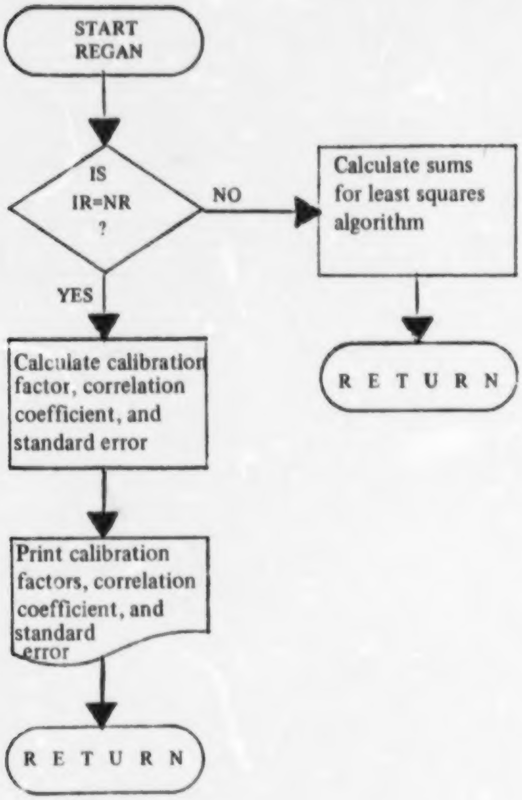

START REGAN
IS IR=NR ?
NO
YES
Calculate sums for least squares algorithm
RETURN
Calculate calibration factor, correlation coefficient, and standard error
Print calibration factors, correlation coefficient, and standard error
RETURN

Figure 4-4 Subroutine REGAN

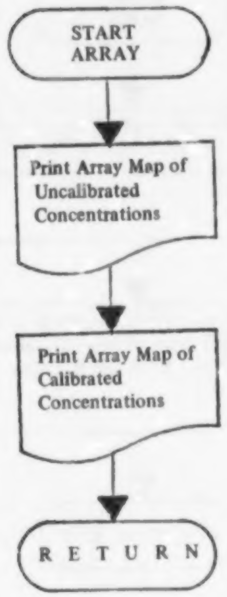

START ARRAY
Print Array Map of Uncalibrated Concentrations
Print Array Map of Calibrated Concentrations
RETURN

Figure 4-5 Subroutine ARRAY

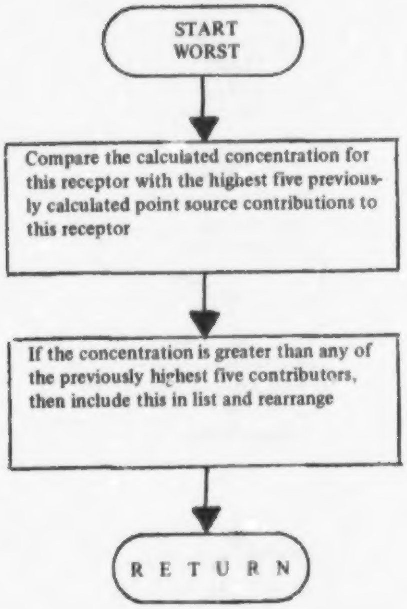

START
WORST
Compare the calculated concentration for this receptor with the highest five previously calculated point source contributions to this receptor
If the concentration is greater than any of the previously highest five contributors, then include this in list and rearrange
RETURN

Figure 4-6 Subroutine WORST

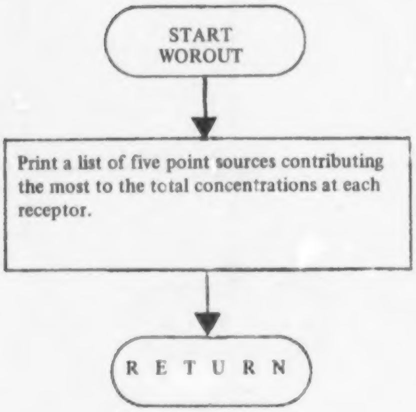

START
WOROUT
Print a list of five point sources contributing the most to the total concentrations at each receptor.
R E T U R N

Figure 4-7 Subroutine WOROUT

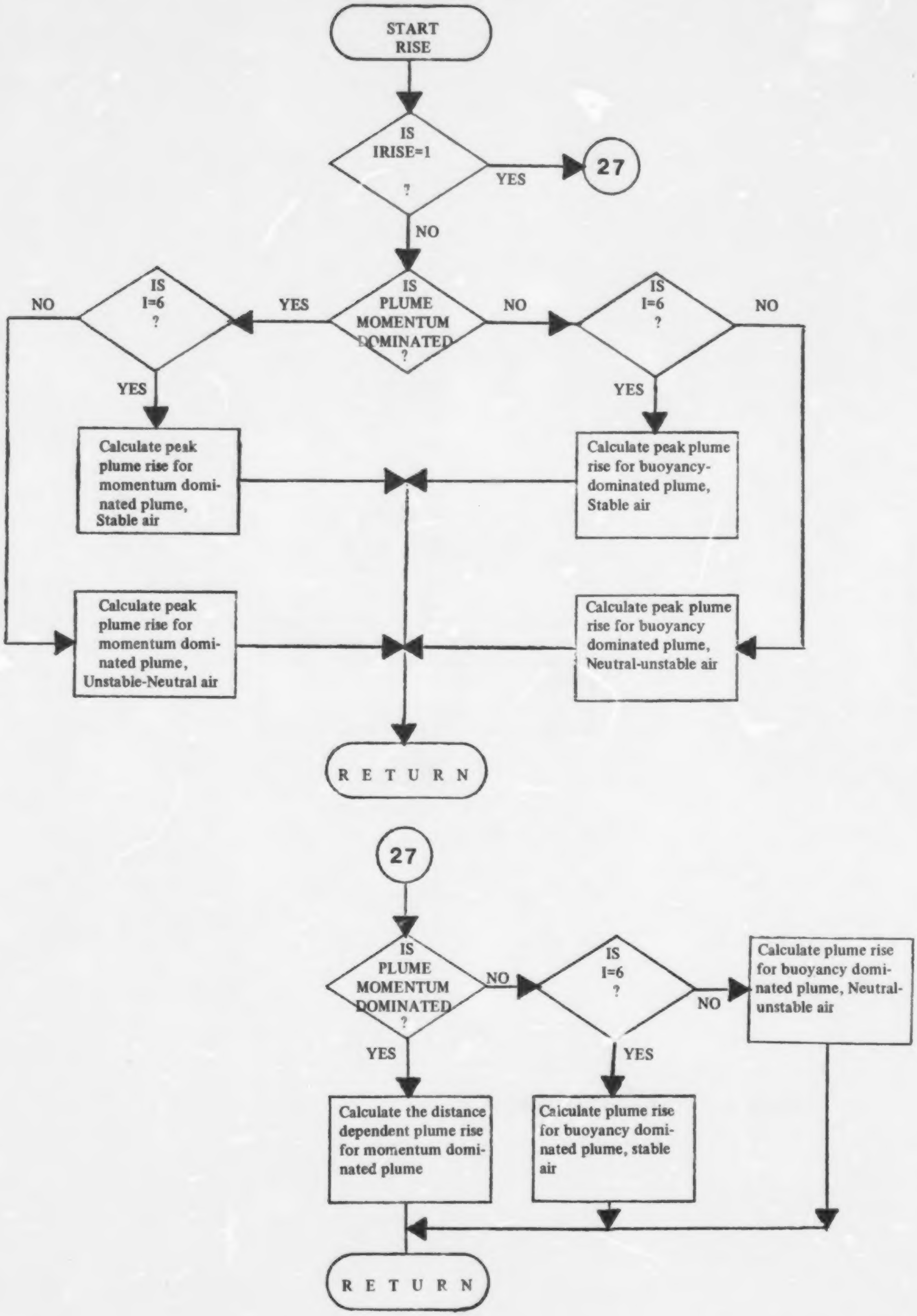

START RISE
IS IRISE=1 ?
YES
27
NO
IS PLUME MOMENTUM DOMINATED ?
YES
NO
IS I=6 ?
NO
YES
IS I=6 ?
NO
YES
Calculate peak plume rise for momentum dominated plume, Stable air
Calculate peak plume rise for buoyancy-dominated plume, Stable air
Calculate peak plume rise for momentum dominated plume, Unstable-Neutral air
Calculate peak plume rise for buoyancy dominated plume, Neutral-unstable air
RETURN
27
IS PLUME MOMENTUM DOMINATED ?
NO
YES
IS I=6 ?
NO
YES
Calculate plume rise for buoyancy dominated plume, Neutral-unstable air
Calculate the distance dependent plume rise for momentum dominated plume
Calculate plume rise for buoyancy dominated plume, stable air
RETURN

Figure 4-8 Subroutine RISE

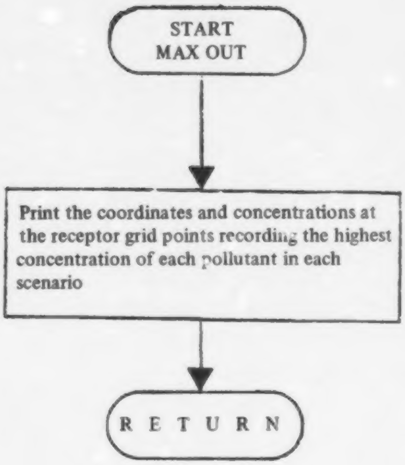

START
MAX OUT
Print the coordinates and concentrations at the receptor grid points recording the highest concentration of each pollutant in each scenario
RETURN

Figure 4-9 Subroutine MAXOUT

APPENDIX A

General Form of the Gaussian Equation

The most general form of the Gaussian dispersion equation is:

$$\chi(x,y,z,H) = \frac{Q}{2\pi U \sigma_y \sigma_z} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] \left\{ \exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right] + \exp\left[-\frac{(z+H)^2}{2\sigma_z^2}\right] \right\} \quad (18)$$

For ground level concentrations z=0 and equation (18) simplifies to:

$$\chi(x,y,0,H) = \frac{Q}{\pi U \sigma_y \sigma_z} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] \exp\left[-\frac{H^2}{2\sigma_z^2}\right] \quad (19)$$

where:

Q is the source emission rate, grams per second
U is the average wind speed at stack height, meters per second
σ_y, σ_z are the standard deviations of the concentration distributions in the crosswind and vertical directions respectively, meters
H is the effective stack height, which is the sum of stack height and plume rise, meters
x is the distance downwind from the stack, meters
y is the crosswind distance from the plume centerline, meters
z is the vertical distance from ground level, meters

The coordinate system used in equation (18) is illustrated in Figure A-1. This rectangular coordinate system will be transformed to a polar coordinate system as illustrated in Figure A-2. The origin is located at the source and angular coordinates are measured in a clockwise direction from the direction that corresponds to North.

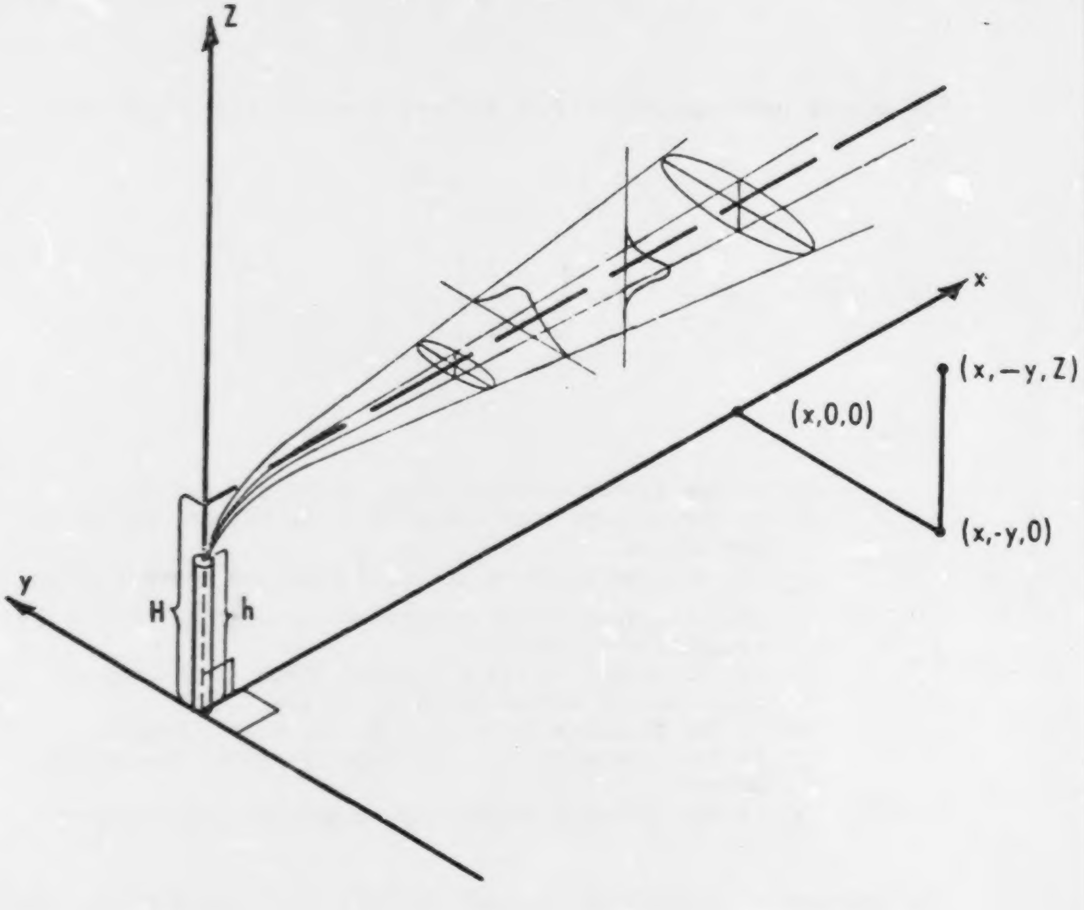


Figure A-1 Coordinate System for the Gaussian Plume Equation

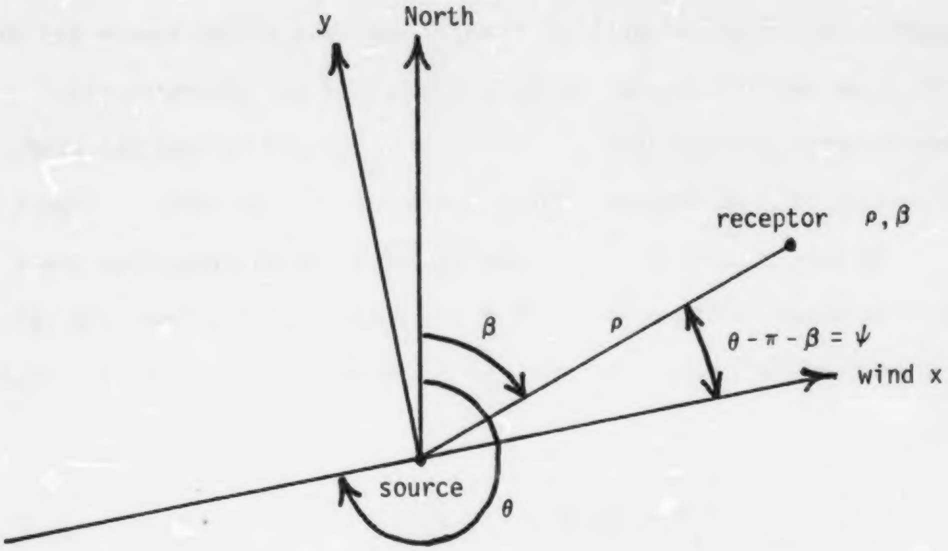


Figure A-2 Polar Coordinate System Used for TCM-2.

Assume that the wind blows from angle θ. Let $f(\theta)$ represent the frequency function of the wind direction θ where $\int_{\theta}^{\theta+\xi} f(\theta)$ is the probability that the wind direction is in the range from θ to $\theta+\xi$. Let Δ be the angular width of the plume, which is normally a relatively small angle. Then consider a receptor located at the point (ρ,β). This receptor will be directly downwind of the source and on the plume centerline when the wind blows from the direction $\pi+\beta$. The receptor will receive pollutants from the source when the wind direction is from between $\pi+\beta+\frac{\Delta}{2}$ and $\pi+\beta-\frac{\Delta}{2}$ as shown in Figure A-3.

In the rectangular coordinate system the wind blows down the x axis as shown in Figure A-2. Thus the relationship between the polar and rectangular coordinates for the receptor located at $(x,y) = (\rho,\beta)$ is:

$$x = \rho \cos(\theta - \pi - \beta)$$
$$y = \rho \sin(\theta - \pi - \beta).$$

Then the average concentration at this receptor is:

$$\overline{X} = \int_{\pi+\beta-\frac{\Delta}{2}}^{\pi+\beta+\frac{\Delta}{2}} X[\rho\cos(\theta-\beta-\pi),\ \rho\sin(\theta-\beta-\pi),\ z,H]f(\theta)\,d\theta \qquad (20)$$

Making the bounds of integration larger than $\pi+\beta+\frac{\Delta}{2}$ or smaller than $\pi+\beta-\frac{\Delta}{2}$ would have no effect upon the value of $\overline{X}$ since the receptor would not receive additional contributions from the source.

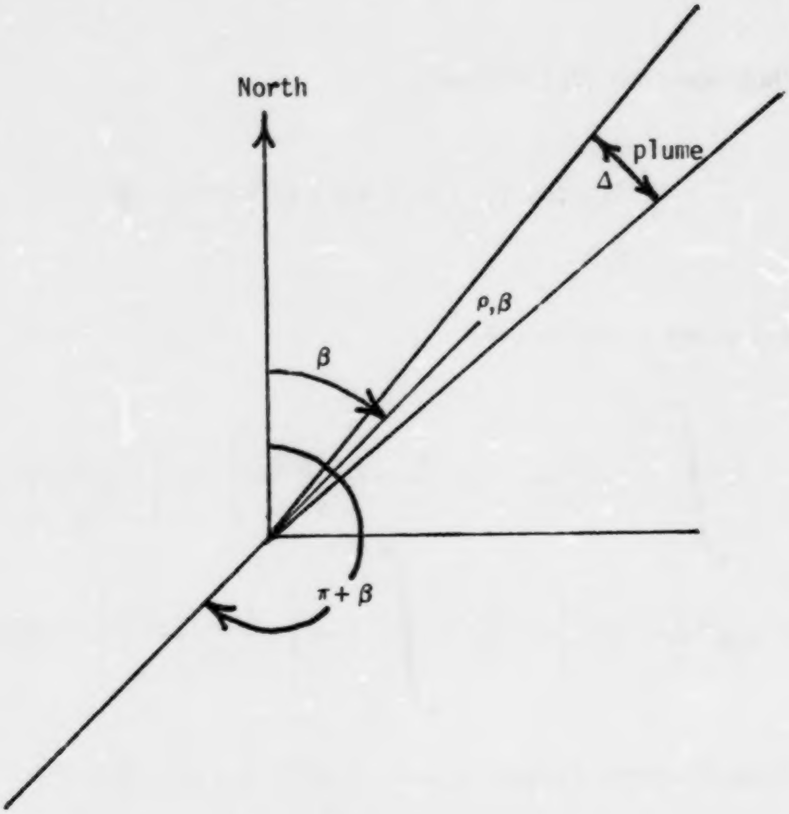


Figure A-3 Source, Plume, and Receptor Relationships

Now let $\psi = \theta-\beta-\pi$

Then $\theta=\psi+\beta+\pi$ and $d\theta=d\psi$

If $\theta=\pi+\beta+\frac{\Delta}{2}$, then $\psi=\frac{\Delta}{2}$ and

if $\theta=\pi+\beta-\frac{\Delta}{2}$, then $\psi=\frac{-\Delta}{2}$

Thus equation (20) becomes

$$\overline{X} = \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} \chi[\rho\cos\psi, \rho\sin\psi\ z, H]\ f\ (\psi+\beta+\pi\ )\ d\psi$$

and using equation (19)

$$\overline{X} = \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} \frac{Q}{\pi U\sigma_y\sigma_z} \exp\left[-\frac{(\rho\sin\psi)^2}{2\sigma_y^2}\right] \exp\left[-\frac{H^2}{2\sigma_z^2}\right] f(\psi+\beta+\pi)d\psi$$

$$= \frac{Q}{\pi U\sigma_y\sigma_z} \exp\left[-\frac{H^2}{2\sigma_z^2}\right] \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} \exp\left[-\frac{(\rho\sin\psi)^2}{2\sigma_y^2}\right] f(\psi+\beta+\pi)d\psi$$

Since ψ ranges between $\frac{-\Delta}{2}$ and $\frac{\Delta}{2}$, with Δ small, $\psi \approx \sin\psi$ so

$$\overline{X} = \frac{Q}{\pi U\sigma_y\sigma_z} \exp\left[-\frac{H^2}{2\sigma_z^2}\right] \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} \exp\left[-\frac{\rho^2\psi^2}{2\sigma_y^2}\right] f(\psi+\beta+\pi)d\psi$$

Also since ψ ranges between $\frac{-\Delta}{2}$ and $\frac{\Delta}{2}$, the value for $f(\psi+\beta+\pi)$ varies very little, so $f(\psi+\beta+\pi)$ can be replaced by $f(\beta+\pi)$ and

$$\overline{X} = \frac{Q}{\pi U\sigma_y\sigma_z} \exp\left[-\frac{H^2}{2\sigma_z^2}\right] f(\beta+\pi) \int_{-\frac{\Delta}{2}}^{\frac{\Delta}{2}} \exp\left[-\frac{\rho^2\psi^2}{2\sigma_y^2}\right] d\psi$$

Let $w = \frac{\rho\psi}{\sigma_y}$. Then $dw = \frac{\rho}{\sigma_y} d\psi$ and $d\psi = \frac{\sigma_y}{\rho} dw$. If $\psi = \frac{\Delta}{2}$, then $w = \frac{\rho\Delta}{2\sigma_y}$.

Thus $$\overline{X} = \frac{Q}{\pi U \sigma_y \sigma_z} \exp\left[-\frac{H^2}{2\sigma_z^2}\right] f(\beta+\pi) \int_{-\frac{\rho\Delta}{2\sigma_y}}^{\frac{\rho\Delta}{2\sigma_y}} (\exp[-\tfrac{1}{2} w^2]) \frac{\sigma_y}{\rho}\, dw$$

$$= \frac{Q}{\pi U \sigma_z} \exp\left[-\frac{H^2}{2\sigma_z^2}\right] f(\beta+\pi) \int_{-\frac{\rho\Delta}{2\sigma_y}}^{\frac{\rho\Delta}{2\sigma_y}} \frac{1}{\sigma_y} (\exp[-\tfrac{1}{2} w^2]) \frac{\sigma_y}{\rho}\, dw$$

$$= \frac{Q}{\rho\pi U \sigma_z} \exp\left[-\frac{H^2}{2\sigma_z^2}\right] f(\beta+\pi) \int_{-\frac{\rho\Delta}{2\sigma_y}}^{\frac{\rho\Delta}{2\sigma_y}} \exp[-\tfrac{1}{2} w^2] dw$$

Since $$\frac{1}{\pi} = \left[\frac{1}{\sqrt{2\pi}}\right]\left[\frac{2}{\sqrt{2\pi}}\right]$$

$$\overline{X} = \frac{2Q}{\rho\sqrt{2\pi}U\sigma_z} \exp\left\{\frac{-H^2}{2\sigma_z^2}\right\} f(\beta+\pi) \int_{-\frac{\rho\Delta}{2\sigma_y}}^{\frac{\rho\Delta}{2\sigma_y}} \frac{1}{\sqrt{2\pi}} \exp\left\{-\frac{1}{2} w^2\right\} dw \qquad (21)$$

The integral in equation (21) is the Gaussian probability function, so this value approaches unity as the magnitude of the upper and lower bounds get large. The value of Δ, the width of the plume, is small. But, if the value for Δ is allowed to increase beyond the size of the plume width, the value for $\overline{X}$ will remain unchanged. Thus, the value of the integral does not vary appreciably when Δ varies, so the value of the integral does not vary substantially from unity. Hence equation (21) becomes

$$\overline{X} = \frac{2Q}{\sqrt{2\pi}\rho U \sigma_z} \exp\left\{-\frac{H^2}{2\sigma_z^2}\right\} f(\beta+\pi) \qquad (22)$$

The value for $\overline{X}$ in equation (22) is the average concentration at the receptor for all wind directions, but since the plume width is narrow, it is possible to relate this average concentration to the probability that the wind will be from the direction that places the receptor directly downwind of the source. In this case $\theta = \beta + \pi$ is the direction that places the receptor downwind of the source and on the plume centerline. The value for the frequency function $f(\theta)$ with $\theta = \beta + \pi$ is the probability that the wind will be from that direction. All possible values for wind direction θ can be separated into 16 equally sized wind direction sectors with each sector encompassing 22.5 degrees. Let us assume that $\beta + \pi$ lies within the kth sector. It is further assumed that the probability of occurrence is equal for any wind direction within a given wind direction sector (i.e., $f(\theta)$ is constant within each sector). Let $F(k)$ be the probability that the wind direction lies within the kth sector.

Then $F(k) = \int_{\theta_k}^{\theta_k + \frac{2\pi}{16}} f(\theta)\,d\theta$

Since $f(\theta)$ is constant within the range θ_k to $\theta_k + \frac{2\pi}{16}$,

$$F(k) = f(\theta) \int_{\theta_k}^{\theta_k + \frac{2\pi}{16}} d\theta \qquad = \frac{2\pi}{16} f(\theta)$$

Since $f(\theta)$ is constant within the range θ_k to $\theta_k + \frac{2\pi}{16}$,

and $\theta_k \leq \beta + \pi \leq \theta_k + \frac{2\pi}{16}$

$$F(k) = \frac{2\pi}{16} f(\beta+\pi) \qquad \text{and}$$

$$f(\beta + \pi) = \frac{16}{2\pi} F(k) \qquad (23)$$

Combining equations (22) and (23) we have,

$$\overline{\chi} = \frac{32Q}{(2\pi)^{3/2} \rho U \sigma_z} \left[\exp \left[- \frac{H^2}{2\sigma_z^2} \right] F(k) \right]$$

$$\overline{\chi} = \frac{32Q}{(2\pi)^{3/2} \rho} \; \frac{F(k)}{U\sigma_z} \left[\exp \left[- \frac{H^2}{2\sigma_z^2} \right] \right] \qquad (24)$$

Equation (24) was derived with the wind direction considered as a random variable. An analogous derivation can be performed that also considers wind speed class and atmospheric stability class as random variables. The six national weather service wind speed classes and six Pasquill atmospheric stability classes (atmospheric stability classes D-Day and D-Night are separated while E and F are combined) are considered. Then the probability of each of the 576 possible combinations is given by the meteorological joint frequency function $\Phi(k,\ell,m)$ where k is the wind direction sector index, ℓ is the wind speed class index, and m is the atmospheric stability class index. Thus the average concentration corresponding to all possible combinations of wind direction, wind speed, and atmospheric stability is

$$\overline{X} = \frac{32Q}{(2\pi)^{3/2}\rho} \sum_{\ell=1}^{6} \sum_{m=1}^{6} \frac{\Phi(k,\ell,m)}{U\ell\ \sigma_z(\rho,m)} \exp\left[\frac{-H^2}{2\sigma_z(\rho,m)^2}\right] \qquad (25)$$

Note that $\sigma_z(\rho, m)$ is a function of downwind distance ρ and atmospheric stability class index m. Also the wind direction is still contained in the kth sector (i.e., there is no summation for k in equation (25)).

Except for overcast conditions, atmospheric stability is a weak function of wind speed. To simplify the equation and speed up calculations the central wind speed U_ℓ is replaced with the weighted average wind speed U^*_m for the appropriate atmospheric stability class. Then equation (25) becomes

$$\overline{X} = \frac{32Q}{(2\pi)^{3/2}\rho} \sum_{\ell=1}^{6} \sum_{m=1}^{6} \frac{\Phi(k,\ell,m)}{U^*_m \sigma_z(\rho,m)} \exp\left[\frac{-H^2}{2\sigma_z(\rho,m)^2}\right]$$

$$= \frac{32Q}{(2\pi)^{3/2}\rho} \sum_{m=1}^{6} \frac{\sum_{\ell=1}^{6} \Phi(k,\ell,m)}{U^*_m \sigma_z(\rho,m)} \exp\left[\frac{-H^2}{2\sigma_z(\rho,m)^2}\right]$$

$$= \frac{32Q}{(2\pi)^{3/2}\rho} \sum_{m=1}^{6} \frac{\Phi(k,m)}{U^*_m \sigma_z(\rho,m)} \exp\left[\frac{-H^2}{2\sigma_z(\rho,m)^2}\right] \qquad (26)$$

where $\Phi(k,m)$ is the probability that the wind direction will be in sector k with atmospheric stability class index m. Note that

$$\Phi\,(k,m) = \sum_{\ell=1}^{6}\,(k,\,\ell,m).$$

APPENDIX B

TCM-2 Area Source Algorithm Derivation

The area source algorithm used in the TCM-2 is based upon an algorithm that was developed by Gifford and Hanna [11]. First integrate equation (18) for plume cross section concentration from $y=-\infty$ to $y=+\infty$ with the 10 minute value for σ_y.

$$\int_{-\infty}^{+\infty} \chi\ (x,\ y,\ H)dy = \int_{-\infty}^{+\infty} \frac{Q}{U\pi\sigma_z\sigma_y} \exp\left[-\frac{H^2}{2\ \sigma_z{}^2}\right] \exp\left[-\frac{y^2}{2\sigma_y{}^2}\right] dy$$

$$= \frac{Q}{U\pi\sigma_z\sigma_y} \exp\left[-\frac{H^2}{2\sigma_z{}^2}\right] \int_{-\infty}^{+\infty} \exp\left[-\frac{y^2}{2\sigma_y{}^2}\right] dy$$

Now

$$\int_{0}^{+\infty} \exp\ (-a^2x^2)dx = \frac{1}{2a}\ \sqrt{\pi}$$

$$\int_{-\infty}^{+\infty} \exp\ (-a^2x^2)dx = 2\int_{0}^{+\infty} \exp\ (-a^2x^2)dx = \frac{1}{a}\ \sqrt{\pi} \qquad (27)$$

But

$$\int_{-\infty}^{+\infty} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] dy = \int_{-\infty}^{+\infty} \exp\left[-\left[\frac{1}{\sqrt{2}\ \sigma_y}\right]^2\right] y^2 \quad dy = \sqrt{2\pi}\ \sigma_y$$

Thus

$$C = \int_{-\infty}^{+\infty} \chi(x,\ y,\ H)dy = \frac{Q}{U\pi\sigma_z\sigma_y} \quad \exp\left[-\ \frac{H^2}{2\sigma_z^2}\right] \sqrt{2\pi}\ \sigma_y$$

$$= \frac{\sqrt{2}\ Q}{U\ \sqrt{\pi}\,\sigma_z} \quad \exp\left[-\ \frac{H^2}{2\,\sigma_z^2}\right]$$

For an area source, emissions are assumed to be emitted at the ground level so

$$C = \sqrt{\frac{2}{\pi}}\ \frac{Q}{U^*(m)\,\sigma_z} \tag{28}$$

Equation (28) represents the total amount of pollutants in the cross section of the plume. Now use

$$\sigma_z = a(m)\ x^{b(m)} \tag{29}$$

to approximate σ_z and substitute into equation (28)

$$C = \sqrt{\frac{2}{\pi}}\left\{\frac{1}{U^*(m)a(m)}\right\}\ Qx^{-b(m)} \tag{30}$$

Define a rectilinear array of calculation squares each of the same size with a distance of Δx on each side. (This is done in TCM-2 by shifting receptor grid squares as described in Section 2.2.2). It is assumed that the area source is the size of one of the calculation squares and that the emissions originate in the center of the square. It is also initially assumed that the wind blows down the x axis. A receptor is located in the center of the calculation square covered by the area source and in the center of each of four calculation squares downwind of the source. For each i, i = 1, 2, 3, 4, let x_i be the distance from the *ith* receptor to the center of the area source. Then $x_i = i\Delta x$ and the distance from the center of the source to the upwind site of the *ith* calculation square is:

$$x_i - \frac{\Delta x}{2} = i\Delta x - \frac{\Delta x}{2} = (2_i - 1)\frac{\Delta x}{2}$$

Also the distance from the source to the downwind side of the *ith* calculation square is:

$$x_i + \frac{\Delta x}{2} = i\Delta x + \frac{\Delta x}{2} = (2_i + 1)\frac{\Delta x}{2}$$

See Figure B-1.

The average concentration over the *ith* calculation square, represented as the concentration at the receptor within the *ith* square is:

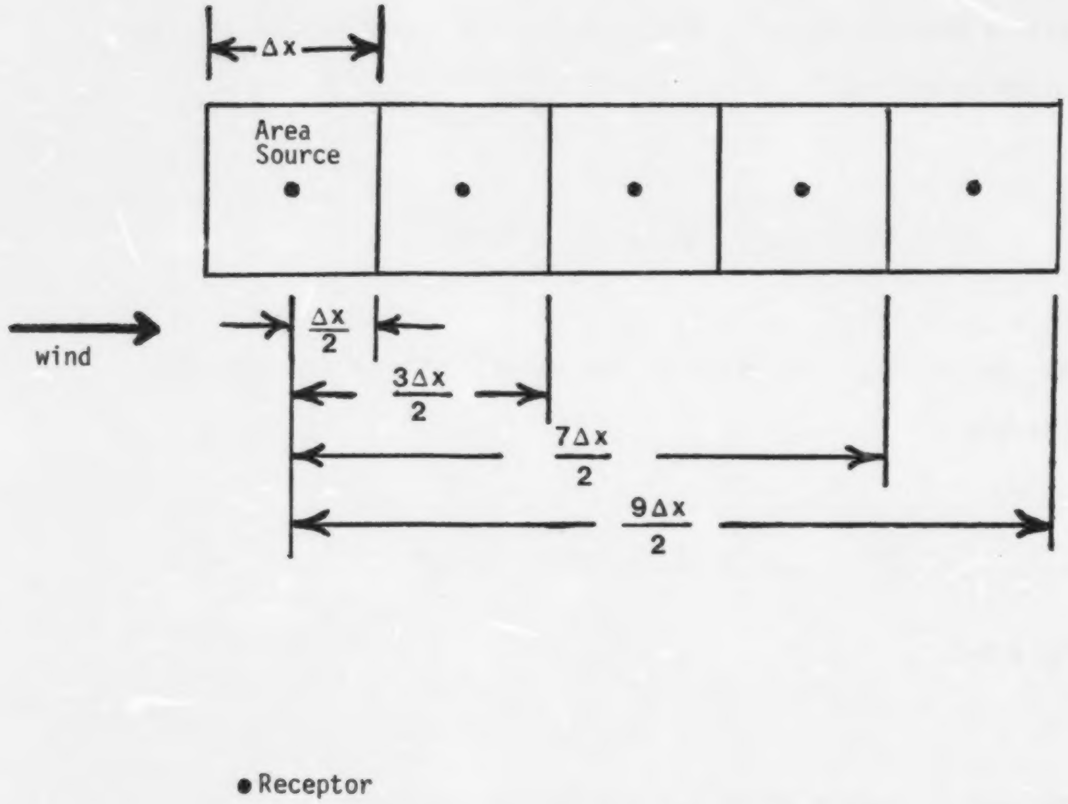


Figure B-1 Area Source Geometry with Affected Downwind Calculation Grid Squares

$$C_A = \int_{(2i-1)\frac{\Delta x}{2}}^{(2i+1)\frac{\Delta x}{2}} C \quad dx$$

$$= \int_{(2i-1)\frac{\Delta x}{2}}^{(2i+1)\frac{\Delta x}{2}} \sqrt{\frac{2}{\pi}} \frac{1}{U^*(m)a(m)} Q \quad x^{-b(m)} \quad dx$$

$$= \sqrt{\frac{2}{\pi}} \frac{Q}{U^*(m)a(m)} \int_{(2i-1)\frac{\Delta x}{2}}^{(2i+1)\frac{\Delta x}{2}} x^{-b(m)} \quad dx$$

$$= \sqrt{\frac{2}{\pi}} \frac{Q}{U^*(m)a(m)} \left\{ \frac{1}{1-b(m)} \left[\left\{ (2i + 1) \frac{\Delta x}{2} \right\}^{1-b(m)} - \left\{ (2i - 1)\frac{\Delta x}{2} \right\}^{1-b(m)} \right] \right\}$$

$$= \sqrt{\frac{2}{\pi}} \frac{Q}{U^*(m)a(m)[1-b(m)]} \left\{\frac{\Delta x}{2}\right\}^{1-b(m)} \left\{(2i + 1)^{1-b(m)} - (2i - 1)^{1-b(m)}\right\} \qquad (31)$$

In general the wind does not blow down the x axis. The mechanism used in TCM-2 for adjusting the pattern of receptors relative to wind direction is described in Section 2.2.2. The concentration in the ith calculation is the same for all wind directions. Equation (31) is multiplied by the appropriate value for the meteorological joint frequency function to obtain equation (17).

The average concentration at the receptor located within the calculation square covered by the area source is obtained by integrating across the square containing the area source:

$$C_A = \int_0^{\Delta x} C \; dx$$

$$= \int_0^{\Delta x} \sqrt{\frac{2}{\pi}} \frac{1}{U^*(m) a(m)} Q \, x^{-b(m)} \; dx$$

$$= \sqrt{\frac{2}{\pi}} \frac{Q}{U^*(m) a(m)} \int_0^{\Delta x} x^{-b(m)} \; dx$$

$$= \sqrt{\frac{2}{\pi}} \frac{Q}{U^*(m) a(m)} \left[\frac{1}{1-b(m)} \left(\Delta x \right)^{1-b(m)} \right]$$

$$= \sqrt{\frac{2}{\pi}} \frac{Q}{U^*(m) a(m) \, [1-b(m)]} \left(\Delta x \right)^{1-b(m)} \qquad (32)$$

Equation (32) is multiplied by the appropriate value for the meteorological joint frequency function to obtain equation (16).

APPENDIX C

Derivation of Flare Input as a Point Source

As indicated in Section 2.3.1, flares can be modeled as a point source with the TCM-2 by using a set of arbitrary dummy variables for stack temperature, stack velocity, and stack diameter. The nature of a flare prevents accurate estimates of these parameters for model inputs.

The strategy is to find dummy variables that will predict a reasonable plume rise. It is desirable to minimize the variation in F, the buoyancy flux component, when a variety of ambient temperatures are used.

$$F = \frac{gVD^2}{4} \left(\frac{T-T_A}{T} \right) \qquad (34)$$

where =

F is the buoyancy flux
g is the gravitational constant, meters per second squared
V is the stack temperature, meters per second
D is the stack diameter, meters
T is the stack temperature, degrees K
T_A is the ambient temperature, degrees K

Let T = 1000°C and allow T_A to vary from 0°C to 40°C (reasonable extreme ambient temperatures for most sites in Texas). If all other variables in equation (34) remain constant, then there is a 4% difference between F values calculated for TA = 0°C and TA = 40°C.

Briggs [7] gives an alterante parameterization of F as:

$$F = 3.7 \times 10^{-5}\, q_n \qquad (35)$$

where q_n is the heat release in cal/sec.

Equating equations (34) and (35)

$$3.7 \times 10^{-5} \, q_n = \frac{gVD^2}{4} \left(\frac{T-T_A}{T} \right)$$

Arbitrarily set V = 20 m/s, T = 1000°C, and T_A = 35°C.

Then,

$$3.7 \times 10^{-5} \, q_n = \frac{(9.8)(20)D^2}{4} \; \frac{1273 - 308}{1273}$$

Thus

$$q_n = 1003906D^2$$

and $$D = \sqrt{q_n} \times 10^{-3}$$

APPENDIX D

EXAMPLE PRINT OUT OF METEOROLOGICAL JOINT FREQUENCY FUNCTION

```
 HOUSTON HOBBY AIRPORT,1961-1969
   NA    .00009 .00006 .00000 .00000 .00000 .00000      12918  1A 176169
 NNEA    .00010 .00018 .00000 .00000 .00000 .00000      12918  2A 176169
  NEA    .00013 .00020 .00000 .00000 .00000 .00000      12918  3A 176169
 ENEA    .00011 .00024 .00000 .00000 .00000 .00000      12918  4A 176169
   EA    .00023 .00016 .00000 .00000 .00000 .00000      12918  5A 176169
 ESEA    .00007 .00010 .00000 .00000 .00000 .00000      12918  6A 176169
  SEA    .00015 .00024 .00000 .00000 .00000 .00000      12918  7A 176169
 SSEA    .00015 .00028 .00000 .00000 .00000 .00000      12918  8A 176169
   SA    .00033 .00061 .00000 .00000 .00000 .00000      12918  9A 176169
 SSWA    .00008 .00049 .00000 .00000 .00000 .00000      1291810A 176169
  SWA    .00025 .00043 .00000 .00000 .00000 .00000      1291811A 176169
 WSWA    .00019 .00045 .00000 .00000 .00000 .00000      1291812A 176169
   WA    .00006 .00022 .00000 .00000 .00000 .00000      1291813A 176169
 WNWA    .00006 .00020 .00000 .00000 .00000 .00000      1291814A 176169
  NWA    .00006 .00022 .00000 .00000 .00000 .00000      1291815A 176169
 NNWA    .00014 .00012 .00000 .00000 .00000 .00000      1291816A 176169
   NB    .00062 .00126 .00083 .00000 .00000 .00000      12918  1B 176169
 NNEB    .00055 .00069 .00071 .00000 .00000 .00000      12918  2B 176169
  NEB    .00093 .00130 .00087 .00000 .00000 .00000      12918  3B 176169
 ENEB    .00095 .00128 .00087 .00000 .00000 .00000      12918  4B 176169
   EB    .00068 .00115 .00093 .00000 .00000 .00000      12918  5B 176169
 ESEB    .00075 .00103 .00138 .00000 .00000 .00000      12918  6B 176169
  SEB    .00074 .00182 .00134 .00000 .00000 .00000      12918  7B 176169
 SSEB    .00081 .00148 .00184 .00000 .00000 .00000      12918  8B 176169
   SB    .00106 .00194 .00207 .00000 .00000 .00000      12918  9B 176169
 SSWB    .00050 .00105 .00140 .00000 .00000 .00000      1291810B 176169
  SWB    .00066 .00132 .00128 .00000 .00000 .00000      1291811B 176169
 WSWB    .00049 .00120 .00079 .00000 .00000 .00000      1291812B 176169
   WB    .00072 .00126 .00073 .00000 .00000 .00000      1291813B 176169
 WNWB    .00054 .00099 .00061 .00000 .00000 .00000      1291814B 176169
  NWB    .00060 .00073 .00047 .00000 .00000 .00000      1291815B 176169
 NNWB    .00051 .00101 .00057 .00000 .00000 .00000      1291816B 176169
   NC    .00034 .00132 .00290 .00075 .00010 .00000      12918  1C 176169
 NNEC    .00023 .00103 .00215 .00038 .00000 .00000      12918  2C 176169
  NEC    .00026 .00174 .00373 .00057 .00004 .00000      12918  3C 176169
 ENEC    .00039 .00164 .00401 .00043 .00002 .00000      12918  4C 176169
   EC    .00022 .00146 .00470 .00132 .00004 .00000      12918  5C 176169
 ESEC    .00052 .00120 .00496 .00129 .00010 .00000      12918  6C 176169
  SEC    .00020 .00162 .00531 .00113 .00008 .00000      12918  7C 176169
 SSEC    .00028 .00172 .00646 .00261 .00093 .00002      12918  8C 176169
   SC    .00031 .00217 .00590 .00249 .00036 .00004      12918  9C 176169
 SSWC    .00017 .00129 .00367 .00126 .00019 .00000      1291810C 176169
  SWC    .00019 .00122 .00294 .00065 .00000 .00002      1291811C 176169
 WSWC    .00017 .00109 .00221 .00026 .00002 .00000      1291812C 176169
   WC    .00027 .00105 .00217 .00039 .00004 .00000      1291813C 176169
 WNWC    .00018 .00089 .00185 .00038 .00002 .00000      1291814C 176169
  NWC    .00017 .00111 .00140 .00030 .00006 .00000      1291815C 176169
 NNWC    .00029 .00099 .00227 .00043 .00002 .00002      1291816C 176169
   NDD   .00019 .00160 .00417 .00845 .00269 .00026      12918  1DD176169
 NNEDD   .00014 .00118 .00265 .00458 .00097 .00010      12918  2DD176169
  NEDD   .00019 .00168 .00367 .00470 .00036 .00008      12918  3DD176169
 ENEDD   .00027 .00201 .00409 .00573 .00079 .00002      12918  4DD176169
   EDD   .00014 .00154 .00492 .00855 .00186 .00022      12918  5DD176169
 ESEDD   .00025 .00174 .00588 .01313 .00274 .00020      12918  6DD176169
  SEDD   .00021 .00209 .00691 .01279 .00304 .00012      12918  7DD176169
 SSEDD   .00009 .00178 .00760 .03002 .00879 .00036      12918  8DD176169
   SDD   .00021 .00184 .00658 .02113 .00679 .00069      12918  9DD176169
 SSWDD   .00014 .00095 .00292 .00624 .00154 .00029      1291810DD176169
  SWDD   .00010 .00107 .00223 .00326 .00045 .00008      1291811DD176169
 WSWDD   .00003 .00079 .00130 .00166 .00020 .00002      1291812DD176169
```

```
   WDD  .00022 .00107 .00169 .00211 .00049 .00009      1291813DD176169
 WNWDD  .00010 .00107 .00144 .00267 .00099 .00030      1291814DD176169
  NWDD  .00022 .00073 .00182 .00482 .00255 .00055      1291815DD176169
 NNWDD  .00012 .00113 .00319 .00906 .00429 .00093      1291816DD176169
   NDN  .00058 .00201 .00725 .01274 .00312 .00036      12918 1DN176169
 NNEDN  .00072 .00111 .00432 .00504 .00081 .00014      12918 2DN176169
  NEDN  .00082 .00221 .00644 .00338 .00041 .00014      12918 3DN176169
 ENEDN  .00120 .00172 .00608 .00401 .00039 .00010      12918 4DN176169
   EDN  .00103 .00211 .00638 .00407 .00055 .00016      12918 5DN176169
 ESEDN  .00097 .00261 .00841 .00569 .00049 .00020      12918 6DN176169
  SEDN  .00106 .00279 .01219 .00699 .00065 .00012      12918 7DN176169
 SSEDN  .00065 .00259 .01491 .01742 .00192 .00014      12918 8DN176169
   SDN  .00091 .00229 .00997 .00958 .00085 .00006      12918 9DN176169
 SSWDN  .00035 .00091 .00219 .00186 .00039 .00000      1291810DN176169
  SWDN  .00036 .00081 .00120 .00065 .00010 .00000      1291811DN176169
 WSWDN  .00035 .00055 .00075 .00028 .00004 .00000      1291812DN176169
   WDN  .00044 .00061 .00093 .00026 .00000 .00002      1291813DN176169
 WNWDN  .00043 .00093 .00138 .00142 .00028 .00008      1291814DN176169
  NWDN  .00058 .00085 .00239 .00429 .00111 .00041      1291815DN176169
 NNWDN  .00072 .00113 .00419 .01005 .00377 .00047      1291816DN176169
   NEF  .00694 .01151 .00514 .00000 .00000 .00000      12918 1EF176169
 NNEEF  .00325 .00541 .00249 .00000 .00000 .00000      12918 2EF176169
  NEEF  .00531 .01015 .00361 .00000 .00000 .00000      12918 3EF176169
 ENEEF  .00646 .00974 .00172 .00000 .00000 .00000      12918 4EF176169
   EEF  .00725 .00970 .00132 .00000 .00000 .00000      12918 5EF176169
 ESEEF  .00399 .01408 .00359 .00000 .00000 .00000      12918 6EF176169
  SEEF  .01024 .02160 .00821 .00000 .00000 .00000      12918 7EF176169
 SSEEF  .01169 .02435 .01299 .00000 .00000 .00000      12918 8EF176169
   SEF  .01277 .02255 .01009 .00000 .00000 .00000      12918 9EF176169
 SSWEF  .00444 .00954 .00379 .00000 .00000 .00000      1291810EF176169
  SWEF  .00325 .00590 .00179 .00000 .00000 .00000      1291811EF176169
 WSWEF  .00392 .00660 .00120 .00000 .00000 .00000      1291812EF176169
   WEF  .00528 .00744 .00138 .00000 .00000 .00000      1291813EF176169
 WNWEF  .00371 .00535 .00130 .00000 .00000 .00000      1291814EF176169
  NWEF  .00425 .00537 .00253 .00000 .00000 .00000      1291815EF176169
 NNWEF  .00511 .00798 .00517 .00000 .00000 .00000      1291816EF176169
```

APPENDIX E

EXAMPLE OF TCM-2 AREA SOURCE CALCULATIONS DONE AS POINT SOURCES

```
EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS DONE AS POINT SOURCES          00001000
 0.0      0.0           25        25  0.2                                00001100
 1 1 0 0 1 0 0 0 0 1 0 1 1                                              00001200
 20.5                                                                   00001300
 999.9                                                                  00001400
         10.                                                            00001500
PARTICULATE                                                             00001600
CONCENTRATION TIMES 10                                                  00001601
 1.0                                                                    00001700
                                                                        00001800
 1.3 2.5          1.           0.0   200. .001  20.5       AS1          00001900
 3.3 2.5          1.          10.0   400. .001  20.5       AS2          00001901
 2.5 -.5          2.           0.0   200. .001  20.5       AS3          00001902
                                                                        00002000
$END JOB                                                                00002200
```

Card Deck Used For Example of TCM-2 Area Source Calculations
Done as Point Sources

```
                    T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2

                         EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS DONE AS POINT SOURCES

RECEPTOR GRID CONSISTS OF 25 COLUMNS AND 25 ROWS, SPACED  0.200KM. APART.  SOUTHWEST CORNER OF GRID =   0.00KM.,       0.00KM.

                         1 RUN(S) WITH THE FIRST POLLUTANT AND INTPUN =  1
                                RISING STAGE OF PLUME RISE WILL BE USED
                             RURAL DISPERSION WILL BE USED FOR POINT SOURCES

                                TYPES OF OUTPUT TO BE PRODUCED BY THIS RUN:
                                            ARRAY MAP
                                    LIST OF MAXIMUM CONCENTRATIONS

                             DECAY HALF-LIFE OF POLLUTANT 1 =  599.900 HOURS.

---------------------------------------------------------------------------------------------------------------------------

                         AREA SOURCE EMISSION SCALING FACTORS                   CONCENTRATION CALIBRATION FACTORS
RUN NO.  MEAN TEMPERATURE
                                P 1         P 2                             A 1       B 1        A 2        B 2
   1          293.65 K        1.0000      0.0000                          0.0000   10.0000     0.0000     0.0000

                                                                          CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC

---------------------------------------------------------------------------------------------------------------------------

                            METEOROLOGICAL JOINT FREQUENCY FUNCTION FOR RUN 1


                            HOUSTON HOBBY AIRPORT,1961-1969

WIND SECTOR    STABILITY CLASS:      A           B           C           DD          DN          E+F
      1                           0.000940    0.005070    0.011270    0.037240    0.023660    0.045410
      2                           0.000570    0.002950    0.006560    0.012070    0.005610    0.017770
      3                           0.000680    0.003260    0.005020    0.007190    0.003120    0.010930
      4                           0.000640    0.002480    0.003770    0.004000    0.001970    0.011720
      5                           0.000230    0.002710    0.003910    0.005650    0.002160    0.014100
      6                           0.000260    0.002140    0.003330    0.006570    0.004520    0.010360
      7                           0.000280    0.001900    0.003040    0.010590    0.009630    0.012150
      8                           0.000260    0.002190    0.004020    0.018610    0.020330    0.018260
      9                           0.000130    0.002710    0.005410    0.017360    0.026060    0.026490
     10                           0.000230    0.001950    0.003790    0.009520    0.012140    0.011150
     11                           0.000330    0.003100    0.006340    0.010680    0.013400    0.019070
     12                           0.000350    0.003100    0.006490    0.012910    0.013490    0.017920
     13                           0.000390    0.002760    0.007740    0.017230    0.014300    0.018270
     14                           0.000170    0.003160    0.008060    0.023940    0.018370    0.026660
     15                           0.000390    0.003900    0.008340    0.025150    0.023780    0.040050
     16                           0.000430    0.004130    0.012020    0.048640    0.037630    0.048910

MEAN WIND SPEEDS, METERS/SECOND   2.0164      2.4773      3.7335      5.4779      4.4290      2.2390     OVERALL MEAN =  3.2706
```

```
                    T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2

POINT SOURCE LIST:  EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS DONE AS POINT SOURCES                         RUN 1

                                                                                                                      IDENTIFICATION
SOURCE NO.   X (KM)    Y (KM)      HT.(M)   DIAM.(M)   VEL.(M/S)   TEMP.(K)      E1(G/S)      E2(G/S)               AS1
     1        1.30      2.50        0.00    200.000       0.00     293.65         1.000        0.000                AS2
     2        3.30      2.50       10.00    400.000       0.00     293.65         1.000        0.000                AS3
     3        2.50     -0.50        0.00    200.000       0.00     293.65         2.000        0.000

THE SUM OF THE POINT SOURCE EMISSION RATES FOR THIS RUN IS       4.00G/S FOR POLLUTANT 1.      0.00G/S FOR POLLUTANT 2

THE SUM OF THE AREA SOURCE EMISSION RATES FOR THIS RUN IS        0.00G/S FOR POLLUTANT 1.      0.00G/S FOR POLLUTANT 2
```

```
SECTION 1 OF 1   RUN NUMBER 1, POLLUTANT 1 (PARTICULATE ) ,UNCALIBRATED CONCENTRATIONS IN UG/M3          TCM-2  RURAL
                          EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS DONE AS POINT SOURCES

                          METEOROLOGY:     HOUSTON HOBBY AIRPORT,1961-1969

             0.00      0.40      0.80      1.20      1.60      2.00      2.40      2.80      3.20      3.60      4.00      4.40      4.80
    4.80       2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    2    1    1    1    1    1    1    1       4.80
    4.60       2    2    2    2    3    2    2    3    2    2    2    2    2    2    2    2    2    2    2    1    1    1    1    1    0       4.60
    4.40       2    2    2    3    3    3    3    3    3    2    2    2    2    2    2    2    2    2    2    1    1    1    1    1    1       4.40
    4.20       2    2    3    3    3    3    3    3    3    2    2    3    3    3    3    2    2    2    2    1    1    1    1    1    1       4.20
    4.00       2    2    3    3    3    4    3    4    2    2    2    3    3    3    3    3    3    2    1    1    1    1    1    1    1       4.00
    3.80       2    2    3    4    4    4    4    4    3    3    3    3    3    3    4    4    3    3    1    1    1    1    1    1    1       3.80
    3.60       2    3    3    4    5    5    5    5    3    3    3    3    3    4    4    4    4    3    2    1    1    1    1    1    1       3.60
    3.40       3    3    3    4    6    7    7    7    4    3    3    3    3    4    5    5    5    4    2    2    1    1    1    1    1       3.40
    3.20       2    3    4    5    6    9    9    9    5    3    3    3    4    4    5    7    6    6    2    1    1    1    1    1    1       3.20
    3.00       2    3    4    6    8   14   17    7    6    4    4    4    4    5    6    9    9    3    3    2    1    1    1    1    1       3.00
    2.80       2    3    4    6    8   17   37   13    6    5    4    4    4    5    5    8   12    4    3    2    2    1    1    1    1       2.80
    2.60       2    2    3    5   10   21  115   33    9    5    4    4    4    4    6    9    9    4    3    2    2    2    1    1    1       2.60
    2.40       2    2    3    5    7   15   59   40    9    5    5    4    4    4    5    6    6    4    3    2    2    2    1    1    1       2.40
    2.20       2    2    3    4    6   10   11   17    8    5    4    4    4    4    5    5    4    6    3    2    2    1    1    1    1       2.20
    2.00       2    2    3    4    5    5    6    8    7    5    4    4    4    4    4    3    3    4    4    2    2    1    1    1    1       2.00
    1.80       2    2    3    3    4    4    7    7    6    4    4    4    4    4    4    2    4    4    3    2    2    1    1    1    1       1.80
    1.60       2    2    3    3    3    3    6    6    5    5    4    4    4    4    4    2    3    3    3    2    1    1    1    1    1       1.60
    1.40       2    2    3    2    3    3    4    5    5    5    5    4    4    4    4    2    3    3    2    2    2    1    1    1    1       1.40
    1.20       2    2    2    2    3    3    4    5    5    5    5    4    4    4    4    2    3    3    2    2    2    1    1    1    1       1.20
    1.00       2    2    2    2    3    3    4    4    5    5    5    6    5    5    2    2    3    3    2    2    1    1    1    1    1       1.00
    0.80       2    2    2    2    3    4    4    4    4    6    6    6    6    5    2    3    3    2    2    2    1    1    1    1    1       0.80
    0.60       2    2    2    2    2    4    4    4    5    6    7    7    7    6    3    3    3    2    2    2    1    1    1    1    1       0.60
    0.40       1    2    2    2    2    3    4    5    5    6   10   12   11   11    4    4    2    2    2    2    1    1    1    1    1       0.40
    0.20       1    2    2    2    2    3    3    4    6    9   10   16   16   16    6    3    3    2    2    1    1    1    1    1    1       0.20
    0.00       1    2    2    2    2    3    3    4    6   10   14   25   31   10    8    4    3    3    2    1    1    1    1    1    1       0.00
             0.00      0.40      0.80      1.20      1.60      2.00      2.40      2.80      3.20      3.60      4.00      4.40      4.80
```

```
SECTION 1 OF 1   RUN NUMBER 1, POLLUTANT 1 (PARTICULATE ) ,CALIBRATED CONCENTRATIONS (CONCENTRATION TIMES 10      ) TCM-2  RURAL
                 EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS DONE AS POINT SOURCES

                   METEOROLOGY:    HOUSTON HOBBY AIRPORT,1961-1969


          0.00     0.40     0.80     1.20     1.60     2.00     2.40     2.80     3.20     3.60     4.00     4.40     4.80

  4.80.   20  20   21  22   23  22   23  23   23  19   19  19   20  20   20  18   17  17   14   7    7   6    6   6    6          4.80
  4.60    20  22   23  24   25  24   25  25   25  18   21  21   22  22   21  19   19  19   15   8    7   7    7   6    5          4.60
  4.40    18  23   24  27   28  27   28  28   27  19   20  23   24  23   24  22   22  21   17   8    8   8    7   6    5          4.40
  4.20    20  25   27  28   31  30   31  31   31  21   22  26   27  26   27  24   24  24   19   9    9   9    9   6    6          4.20
  4.00    21  23   29  31   33  35   35  36   24  24   25  25   28  29   31  31   28  23   11  11   10   9    7   6    6          4.00
  3.80    23  25   27  36   38  41   38  42   27  27   28  26   27  34   35  37   33  29   13  12   11   9    7   7    6          3.80
  3.60    25  29   31  41   45  48   45  46   28  31   31  29   30  39   42  44   39  34   15  14   13   9    8   7    7          3.60
  3.40    27  31   35  39   63  70   67  68   36  34   31  33   35  37   49  53   48  42   18  15   11  10    9   9    7          3.40
  3.20    23  28   39  53   64  95   94  95   45  33   32  31   32  43   47  67   62  55   22  14   13  11   10   9    8          3.20
  3.00    23  29   39  62   82 138  169  68   60  41   36  36   36  49   57  96   90  32   29  17   15  12   11   9    9          3.00
  2.80    25  29   43  57   80 173  375 133   62  48   41  40   40  46   55  84  123  41   26  19   16  13   11  10    7          2.80
  2.60    21  25   34  49   96 2091152 329   91  53   44  40   34  42   63  78   87  42   25  21   19  15   13  10    9          2.60
  2.40    22  25   35  50   72 148  583 400   91  54   45  41   39  44   50  60   56  41   28  22   19  16   13  10    9          2.40
  2.20    21  24   33  42   62  99  109 167   77  49   40  39   37  41   46  55   39  58   32  21   17  14   11   9    8          2.20
  2.00    21  24   31  39   48  51   59  85   74  49   45  37   37  39   43  28   30  43   38  22   19  12   10   9    8          2.00
  1.80    21  24   27  35   40  42   72  73   59  45   44  39   37  39   41  24   41  41   30  19   17  13   10   9    8          1.80
  1.60    21  23   26  29   29  32   57  60   52  51   42  38   39  40   35  21   34  33   26  23   14  12   11  10    7          1.60
  1.40    21  23   25  24   26  28   41  49   46  47   49  40   41  39   39  20   30  29   23  19   17  11   10   9    8          1.40
  1.20    21  22   25  24   26  28   39  48   47  49   50  42   43  41   40  21   28  26   21  17   15  11   10   9    8          1.20
  1.00    17  18   22  24   26  28   39  41   49  52   54  56   45  46   22  21   27  26   17  16   14  13   10   9    8          1.00
  0.80    17  16   17  24   27  35   38  41   45  57   60  62   56  53   24  28   27  20   19  16   14  13   12   8    8          0.80
  0.60    15  15   19  20   22  36   39  43   47  64   70  73   65  63   27  30   28  20   19  15   14  12   11   8    8          0.60
  0.40    15  16   18  20   22  29   41  46   52  56  104 117  109 109   41  40   22  20   18  15   13  12   11  10    7          0.40
  0.20    15  16   19  20   23  29   33  39   57  94  103 164  159 159   57  34   29  21   18  15   13  12   11  10    9          0.20
  0.00    15  16   18  21   23  30   34  41   60 103  139 248  307 103   84  43   33  26   18  15   13  12   11  10    9          0.00
          0.00     0.40     0.80     1.20     1.60     2.00     2.40     2.80     3.20     3.60     4.00     4.40     4.80
```

```
                         T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2  (R U R A L)

                              HIGHEST PREDICTED CONCENTRATICNS FOR EACH POLLUTANT FJR EACH SCENARIO

                               EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS DONE AS POINT SOURCES

----------------------------------------------------------------------------------------------------------------------

   RUN          METECROLOGY
  NUMBER      .

    1           HOUSTON HOBBY AIRPORT,1961-1969


----------------------------------------------------------------------------------------------------------------------

UNCALIBRATED CONCENTRATIONS IN MICROGRAMS  PER CUBIC METER

   RUN        POLLUTANT 1 CALIBRATION                                        POLLUTANT 2 CALIBRATION
  NUMBER          A 1          B 1                                               A 2          B 2

    1         0.0000      10.0000     CONCENTRATION TIMES 10                  0.0000       0.0000

CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC


----------------------------------------------------------------------------------------------------------------------

                     RECEPTOR COORDINATES      POLLUTANT 1 (PARTICULATE )     RECEPTOR COORDINATES      POLLUTANT 2 (             )
    RUN                                        UNCALIBRATED    CALIBRATED                               UNCALIBRATED     CALIBRATED
   NUMBER           X (KM)       Y (KM)        CONCENTRATION  CONCENTRATION     X (KM)      Y (KM)      CONCENTRATION  CONCENTRATION

     1              1.200        2.600         115.2240       1152.2399
```

APPENDIX F

EXAMPLE OF TCM-2 AREA SOURCE CALCULATIONS

```
EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS                                           00001000
 0.0       0.0               25        25  0.2                                     00001100
 1 1 0 0 1 0 0 0 0 1 0 1 1                                                         00001200
 20.5                                                                              00001300
 999.9                                                                             00001400
           10.                                                                     00001500
PARTICULATE                                                                        00001600
CONCENTRATION TIMES 10                                                             00001601
 1.0                                                                               00001700
 1.3  2.5    200.    1.                                             AS1            00001900
 3.3  2.5    400.    1.                                             AS2            00001901
 2.5  -.5    200.    2.                                             AS3            00001902
                                                                                   00002000
                                                                                   00002100
                                                                                   00002200
```

Card Deck For Example of TCM-2 Area Source Calculations

```
                    T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2

                  EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS

RECEPTOR GRID CONSISTS OF 25 COLUMNS AND 25 ROWS, SPACED  0.200KM. APART.  SOUTHWEST CORNER OF GRID =   0.00KM.,      0.00KM.

                              1 RUN(S) WITH THE FIRST POLLUTANT AND INTPUN =  1
                                   RISING STAGE OF PLUME RISE WILL BE USED
                                 RURAL DISPERSION WILL BE USED FOR POINT SOURCES

                                   TYPES OF OUTPUT TO BE PRODUCED BY THIS RUN:
                                                ARRAY MAP
                                      LIST OF MAXIMUM CONCENTRATIONS

                                 DECAY HALF-LIFE OF POLLUTANT 1 =  999.900 HOURS.

-------------------------------------------------------------------------------------------------------------------------------

                          AREA SOURCE EMISSION SCALING FACTORS                   CONCENTRATION CALIBRATION FACTORS
RUN NO.  MEAN TEMPERATURE
                                  P 1        P 2                              A 1       B 1        A 2        B 2
   1           293.65 K          1.0000     0.0000                          0.0000    10.0000     0.0000     0.0000

                                                                         CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC

-------------------------------------------------------------------------------------------------------------------------------

                                 METEOROLOGICAL JOINT FREQUENCY FUNCTION FOR RUN 1


                                 HOUSTON HOBBY AIRPORT,1961-1969

WIND SECTOR   STABILITY CLASS:       A            B            C            DD           DN           E+F
     1                           0.000940     0.005070     0.011270     0.037240     0.023660     0.045410
     2                           0.000570     0.002950     0.006560     0.012070     0.005610     0.017770
     3                           0.000680     0.003260     0.005020     0.007190     0.003120     0.010730
     4                           0.000640     0.002450     0.003770     0.004000     0.001970     0.011720
     5                           0.000280     0.002710     0.003910     0.005650     0.002160     0.014100
     6                           0.000260     0.002140     0.003330     0.006570     0.004520     0.010360
     7                           0.000230     0.001900     0.003040     0.010590     0.009630     0.012150
     8                           0.000260     0.002190     0.004020     0.016610     0.020330     0.018260
     9                           0.000150     0.002710     0.005410     0.017360     0.026060     0.026490
    10                           0.000240     0.001950     0.003790     0.009620     0.012140     0.011150
    11                           0.000330     0.003100     0.006340     0.010680     0.013400     0.019070
    12                           0.000350     0.003100     0.006490     0.012910     0.013490     0.017920
    13                           0.000390     0.002760     0.007740     0.017230     0.014300     0.015270
    14                           0.000170     0.003160     0.008060     0.023940     0.018370     0.026660
    15                           0.000390     0.003900     0.008340     0.025150     0.023780     0.040050
    16                           0.000430     0.004130     0.012020     0.048640     0.037630     0.048910

MEAN WIND SPEEDS, METERS/SECOND    2.0164       2.4773       3.7335       5.4779       4.4290       2.2380     OVERALL MEAN =  3.2706
```

```
                    T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2

AREA SOURCE LIST:  EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS

SOURCE NUMBER    X (KM)   Y (KM)   LENGTH OF SIDE (M)        E1 (G/S)         E2 (G/S)          IDENTIFICATION
      1           1.30     2.50         200.00                1.0000           0.0000            AS1
      2           3.30     2.50         400.00                1.0000           0.0000            AS2
      3           2.50    -0.50         200.00                2.0000           0.0000            AS3

THE SUM OF THE AREA SOURCE EMISSION RATES FOR THIS RUN IS      4.00G/S FOR POLLUTANT 1.      0.00G/S FOR POLLUTANT 2

THE SUM OF THE POINT SOURCE EMISSION RATES FOR THIS RUN IS     0.00G/S FOR POLLUTANT 1.      0.00G/S FOR POLLUTANT 2
```

```
SECTION 1 OF 1   RUN NUMBER 1, POLLUTANT 1 (PARTICULATE ) ,UNCALIBRATED CONCENTRATIONS IN UG/M3              TCM-2  RURAL
                       EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS

                       METEOROLOGY:    HOUSTON HOBBY AIRPORT,1961-1969


        0.00    0.40    0.80    1.20    1.60    2.00    2.40    2.80    3.20    3.60    4.00    4.40    4.80
4.80       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     4.80
4.60       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     4.60
4.40       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     4.40
4.20       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     4.20
4.00       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     4.00
3.80       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     3.80
3.60       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   1   1   1   1   0   0   0   0   0   0     3.60
3.40       0   0   0   0   0   3   3   2   1   1   0   0   0   0   1   2   3   3   2   1   1   0   0   0   0     3.40
3.20       0   0   0   0   3   3   3   3   1   1   1   0   0   0   2   3   4   4   2   1   1   0   0   0   0     3.20
3.00       0   0   0   1   2   3   5   4   1   1   1   1   0   1   2   2   4   8   6   1   1   1   0   0   0     3.00
2.80       0   0   0   1   2   2   6  17   2   1   1   1   0   1   1   2   5  46  44   2   1   1   0   0   0     2.80
2.60       0   0   0   1   1   2  10 152   5   1   1   1   0   1   1   1   4  44  42   2   1   1   0   0   0     2.60
2.40       0   0   0   1   1   2   3  10   2   1   1   1   0   0   1   1   2   4   4   1   1   1   0   0   0     2.40
2.20       0   0   0   1   1   2   1   3   2   1   1   1   0   0   1   1   1   2   2   1   1   1   0   0   0     2.20
2.00       0   0   0   0   1   1   1   2   1   1   1   0   0   0   0   1   1   1   1   1   1   0   0   0   0     2.00
1.80       0   0   0   0   0   1   1   2   1   1   0   0   0   0   0   0   0   1   1   1   0   0   0   0   0     1.80
1.60       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     1.60
1.40       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     1.40
1.20       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     1.20
1.00       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     1.00
0.80       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     0.80
0.60       0   0   0   0   0   0   0   0   0   0   0   5   5   5   2   2   0   0   0   0   0   0   0   0   0     0.60
0.40       0   0   0   0   0   0   0   0   0   0   5   6   7   6   2   2   1   0   0   0   0   0   0   0   0     0.40
0.20       0   0   0   0   0   0   0   0   0   3   4   7   9   8   3   2   1   1   0   0   0   0   0   0   0     0.20
0.00       0   0   0   0   0   0   0   0   0   3   4   5  12  34   3   2   1   1   0   0   0   0   0   0   0     0.00
        0.00    0.40    0.80    1.20    1.60    2.00    2.40    2.80    3.20    3.60    4.00    4.40    4.80
```

```
SECTION 1 OF 1   RUN NUMBER 1, POLLUTANT 1 (PARTICULATE ) ,CALIBRATED CONCENTRATIONS (CONCENTRATION TIMES 10      ) TCM-2  RURAL
                         EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS

                          METEOROLOGY:     HOUSTON HOBBY AIRPORT,1961-1969

             0.00    0.40    0.80    1.20    1.60    2.00    2.40    2.80    3.20    3.60    4.00    4.40    4.80
    4.80       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      4.80
    4.60       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      4.60
    4.40       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      4.40
    4.20       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      4.20
    4.00       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      4.00
    3.80       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      3.80
    3.60       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   7  14  13   8   4   2   0   0   0   0      3.60
    3.40       0   0   0   0   0  27  27  23   8   8   0   0   0   0   6  21  30  23  18   9   6   2   0   0   0      3.40
    3.20       0   0   0   0  25  29  34  29  10   9   7   0   0   4  15  27  36  37  23  10   8   5   1   0   0      3.20
    3.00       0   0   0  15  22  34  46  39  14   9   6   5   0   7  17  24  40  78  59  12   8   6   3   0   0      3.00
    2.80       0   0   0  15  18  24  58 169  15   8   6   5   0   6  14  18  50 462 438  20   8   6   3   0   0      2.80
    2.60       0   0   0  11  13  13 1011519  47  10   7   6   0   5  11  15  41 436 420  21   8   6   3   0   0      2.60
    2.40       0   0   0  10  12  17  29  96  20   9   6   5   0   5  11  15  19  41  40  15   8   6   3   0   0      2.40
    2.20       0   0   0  10  12  17  12  25  19  11   7   5   0   2   9  13  12  16  19  14  10   5   1   0   0      2.20
    2.00       0   0   0   0  13  11   9  19  14  11   8   0   0   0   3   8   8  12  15  12   8   2   0   0   0      2.00
    1.80       0   0   0   0   0   7   7  15  11  11   0   0   0   0   0   2   3   6   7   6   3   0   0   0   0      1.80
    1.60       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      1.60
    1.40       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      1.40
    1.20       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      1.20
    1.00       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      1.00
    0.80       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0.80
    0.60       0   0   0   0   0   0   0   0   0   0   0  55  55  46  17  17   0   0   0   0   0   0   0   0   0      0.60
    0.40       0   0   0   0   0   0   0   0   0   0  50  59  63  57  21  17  13   0   0   0   0   0   0   0   0      0.40
    0.20       0   0   0   0   0   0   0   0   0  29  43  68  91  77  28  18  13  10   0   0   0   0   0   0   0      0.20
    0.00       0   0   0   0   0   0   0   0   0  29  36  49 116 339  31  17  13  10   0   0   0   0   0   0   0      0.00
             0.00    0.40    0.80    1.20    1.60    2.00    2.40    2.80    3.20    3.60    4.00    4.40    4.80
```

```
                    T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2  ( R U R A L )

                         HIGHEST PREDICTED CONCENTRATIONS FOR EACH POLLUTANT FOR EACH SCENARIO

                          EXAMPLE OF TCM2 AREA SOURCE CALCULATIONS

------------------------------------------------------------------------------------------------------------------

  RUN        METEOROLOGY
 NUMBER

   1         HOUSTON HOBBY AIRPORT,1961-1969

------------------------------------------------------------------------------------------------------------------

UNCALIBRATED CONCENTRATIONS IN MICROGRAMS  PER CUBIC METER

  RUN       POLLUTANT 1 CALIBRATION                                     POLLUTANT 2 CALIBRATION
 NUMBER        A 1         B 1                                             A 2         B 2

   1         0.0000      10.0000     CONCENTRATION TIMES 10              0.0000      0.0000

CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC

------------------------------------------------------------------------------------------------------------------

               RECEPTOR COORDINATES    POLLUTANT 1 (PARTICULATE )   RECEPTOR COORDINATES    POLLUTANT 2 (              )
   RUN                                 UNCALIBRATED    CALIBRATED                          UNCALIBRATED     CALIBRATED
  NUMBER        X (KM)     Y (KM)      CONCENTRATION CONCENTRATION   X (KM)     Y (KM)      CONCENTRATION  CONCENTRATION

    1           1.400      2.600        151.9160      1519.1600
```

APPENDIX G

EXAMPLE OF TCM-2 POINT SOURCE CALCULATIONS

```
1000      EXAMPLE OF POINT SOURCES RUN ON TCM2
1100       300.0      3250.00            25           25  1.0
1200       1 3 0 0 1 0 0 0 0 1 0 1 1
1300       20.5
1400       999.9      999.9
1500                  1.25                  1.3333
1600      SO2            PARTICULATE
1700      PERCENT NAAQS                PERCENT NAAQS
1800       1.0        1.0
1900
2000      314.553250.20           170. 111.        14.0 1.50  20.0     300.        1
2100      311.493248.95           300.             75.0 2.50   5.0      45.        2
2200      312.753250.44           200.             45.0 3.00   9.00   1025.        3
2300      303.033266.91          1500. 550.        90.0 1.25  22.00     60.        4
2400
```

Card Deck for Example of TCM-2 Point Source Calculations

```
                    T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2

                  EXAMPLE OF POINT SOURCES RUN ON TCM2

RECEPTOR GRID CONSISTS OF 25 COLUMNS AND 25 ROWS, SPACED  1.000KM. APART.  SOUTHWEST CORNER OF GRID = 300.00KM.,   3250.00KM.

                       1 RUN(S) WITH BOTH THE FIRST AND SECOND POLLUTANTS AND INTPUN =  1
                                    RISING STAGE OF PLUME RISE WILL BE USED
                              RURAL DISPERSION WILL BE USED FOR POINT SOURCES

                                    TYPES OF OUTPUT TO BE PRODUCED BY THIS RUN:
                                                   ARRAY MAP
                                       LIST OF MAXIMUM CONCENTRATIONS

                              DECAY HALF-LIFE OF POLLUTANT 1 =  999.900 HOURS.

                              DECAY HALF-LIFE OF POLLUTANT 2 =  999.900 HOURS.

----------------------------------------------------------------------------------------------------------------------------

                              AREA SOURCE EMISSION SCALING FACTORS                   CONCENTRATION CALIBRATION FACTORS
RUN NO.  MEAN TEMPERATURE
                                      P 1          P 2                               A 1         B 1         A 2         B 2
   1          293.65 K              1.0000       1.0000                            0.0000      1.2500      0.0000      1.3333

                                                                                  CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC

----------------------------------------------------------------------------------------------------------------------------

                                METEOROLOGICAL JOINT FREQUENCY FUNCTION FOR RUN 1

                                      HOUSTON HOBBY AIRPORT,1961-1969

WIND SECTOR   STABILITY CLASS:        A            B            C            DC           DN           E+F
     1                            0.000940     0.005070     0.011270     0.037240     0.023660     0.045410
     2                            0.000570     0.002950     0.006560     0.012070     0.005610     0.017770
     3                            0.000680     0.003260     0.005020     0.007150     0.003120     0.010930
     4                            0.000640     0.002480     0.003770     0.004000     0.001970     0.011720
     5                            0.000280     0.002710     0.003910     0.005650     0.002160     0.014100
     6                            0.000260     0.002140     0.003330     0.006570     0.004520     0.010360
     7                            0.000240     0.001800     0.003040     0.010590     0.009630     0.012150
     8                            0.000250     0.002190     0.004020     0.018610     0.020330     0.018260
     9                            0.000150     0.002710     0.005410     0.017360     0.026060     0.026490
    10                            0.000280     0.001950     0.005790     0.009620     0.012140     0.011150
    11                            0.000330     0.003100     0.006340     0.010680     0.013400     0.019070
    12                            0.000350     0.003100     0.006490     0.012910     0.013450     0.017920
    13                            0.000390     0.002760     0.007740     0.017230     0.014300     0.018270
    14                            0.000170     0.003160     0.009060     0.023940     0.019370     0.026660
    15                            0.000390     0.003900     0.009340     0.025150     0.023780     0.040050
    16                            0.000430     0.004130     0.012020     0.048640     0.037630     0.048910

MEAN WIND SPEEDS, METERS/SECOND   2.0164       2.4773       3.7335       5.4779       4.4290       2.2380     OVERALL MEAN =  3.2706
```

```
                    T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2

POINT SOURCE LIST:  EXAMPLE OF POINT SOURCES RUN ON TCM2                                                     RUN 1

SOURCE NO.   X (KM)    Y (KM)       HT.(M)    DIAM.(M)  VEL.(M/S)   TEMP.(K)      E1(G/S)      E2(G/S)                IDENTIFICATION
     1       314.55   3250.20       14.00      1.500      20.00      573.15       170.000      111.000                      1
     2       311.49   3248.95       75.00      2.500       6.00      318.15       300.000        0.000                      2
     3       312.75   3250.44       45.00      3.000       9.00     1298.15       200.000        0.000                      3
     4       303.03   3286.91       90.00      1.250      22.00      333.15      1500.000      550.000                      4

THE SUM OF THE POINT SOURCE EMISSION RATES FOR THIS RUN IS    2170.00G/S FOR POLLUTANT 1,     661.00G/S FOR POLLUTANT 2

THE SUM OF THE AREA SOURCE EMISSION RATES FOR THIS RUN IS        0.00G/S FOR POLLUTANT 1,       0.00G/S FOR POLLUTANT 2
```

```
SECTION 1 OF 1   RUN NUMBER 1, POLLUTANT 1 (SO2        ) ,UNCALIBRATED CONCENTRATIONS IN UG/M3                    TCM-2  RURAL
                         EXAMPLE OF POINT SOURCES RUN ON TCM2

                         METEOROLOGY:    HOUSTON HOBBY AIRPORT,1961-1969

            300.00  302.00  304.00  306.00  306.00  310.00  312.00  314.00  316.00  318.00  320.00  322.00  324.00
 3274.00     9 14 14 14 14 14 13 12 12 12 11 11  9  9  9  8  9  6  5  6  4  4  4  3  3    3274.00
 3273.00     9 14 14 14 14 14 13 12 12 12 11 11 11  8  8  8  8  6  6  6  4  4  4  4  3    3273.00
 3272.00     9 13 13 14 14 14 12 12 12 11 11 11 11  9  8  8  8  6  6  4  4  4  4  4  4    3272.00
 3271.00    12 13 13 13 13 13 14 12 12 11 11 11 11 10  8  8  6  6  6  4  4  4  4  4  4    3271.00
 3270.00    12 12 13 13 13 13 13 12 12 11 11 11 11 10 10  8  6  6  6  4  4  4  4  4  4    3270.00
 3269.00    12 12 13 13 13 13 13 12 12 12 11 11 11 10 10  8  7  6  6  4  4  4  4  4  4    3269.00
 3268.00    11 12 12 13 13 13 13 12 12 12 11 11 11 11 10 10  7  6  6  4  4  5  4  4  4    3268.00
 3267.00    11 11 12 12 13 13 13 12 12 12 11 11 11 11 10 10  9  6  4  4  4  4  4  4  3    3267.00
 3266.00    10 11 12 12 13 13 13 14 12 12 11 11 11 11 11  9  8  8  4  4  4  4  4  4  3    3266.00
 3265.00    10 11 12 12 12 13 14 14 13 12 12 12 11 11 11  9  8  8  4  4  4  4  4  4  3    3265.00
 3264.00    10 10 12 12 12 12 14 14 13 12 12 12 11 11 11  9  8  8  6  4  4  4  4  4  3    3264.00
 3263.00    10 10 10 12 12 13 14 14 13 12 12 12 12 11 11  9  8  8  6  6  4  4  4  4  3    3263.00
 3262.00    10 10 10 12 12 12 13 14 13 13 13 13 13 12 12  9  8  6  6  6  4  4  4  3  3    3262.00
 3261.00    10 10 10 11 12 12 13 13 15 14 13 13 13 12 10  9  9  6  6  6  5  4  3  3  3    3261.00
 3260.00    10 10 10 11 11 13 13 14 14 15 14 13 13 12 10  9  9  6  6  6  5  5  3  3  3    3260.00
 3259.00     9 10 10 11 11 13 13 13 14 15 14 14 14 13 10  9  9  6  6  6  5  5  3  3  3    3259.00
 3258.00     9 10 10 11 11 11 13 14 15 14 15 15 15 14 11 10 10  6  6  6  5  5  5  3  3    3258.00
 3257.00     9 10 10 10 11 11 12 14 15 15 14 16 16 16 11 10  7  6  6  6  5  5  5  4  3    3257.00
 3256.00     9 10 10 10 11 11 12 15 15 16 15 17 17 14 11 11  7  6  6  5  5  5  5  4  3    3256.00
 3255.00     9  9  9 10 11 11 12 12 16 17 19 16 19 15 12 12  7  6  6  5  5  5  4  4  4    3255.00
 3254.00     9  9  9 10 11 11 12 12 13 19 19 17 17 16 13 12  7  7  6  5  5  4  4  4  4    3254.00
 3253.00     8  9  9 10 10 11 12 13 14 19 19 18 19 17 14 13  8  6  5  5  5  4  4  4  4    3253.00
 3252.00     9  9  9  9 10 10 12 13 14 15 21 19 20 14 16  9  7  6  5  5  5  4  4  4  4    3252.00
 3251.00     7  8  9  9 10 10 11 12 13 15 17 24 14 12  9  7  7  6  5  5  5  5  4  4  4    3251.00
 3250.00     7  9  9  9  9  9 10 12 13 15 19 23 15 12  6  5  7  6  6  5  5  5  4  4  4    3250.00
            300.00  302.00  304.00  306.00  308.00  310.00  312.00  314.00  316.00  318.00  320.00  322.00  324.00
```

```
SECTION 1 OF 1   RUN NUMBER 1. POLLUTANT 1 (SO2        ) ,CALIBRATED CONCENTRATIONS (PERCENT NAAQS                ) TCM-2  RURAL
                        EXAMPLE OF POINT SOURCES RUN ON TCM2

                         METEOROLOGY:    HOUSTON HOBBY AIRPORT,1961-1969

             300.00  302.00  304.00  306.00  308.00  310.00  312.00  314.00  316.00  318.00  320.00  322.00  324.00
 3274.00       12  17  18  19  18  18  16  15  15  15  14  14  10  10  10  10  10   8   7   7   5   5   5   4   4    3274.00
 3273.00       12  17  17  17  17  17  16  15  15  15  14  14  13  10  10  10  10   8   7   7   5   5   5   5   4    3273.00
 3272.00       12  17  17  17  17  17  15  15  15  14  14  13  13  10  10  10  10   9   7   5   5   5   5   5   5    3272.00
 3271.00       15  16  17  17  17  17  17  15  15  14  14  13  13  13  10  10   8   7   7   5   5   5   5   5   5    3271.00
 3270.00       15  15  16  17  17  17  17  15  14  14  14  13  13  13  13  10   9   7   7   5   5   5   5   5   5    3270.00
 3269.00       14  15  16  16  17  17  17  15  14  14  14  13  13  13  13  10   9   7   7   5   5   5   5   5   5    3269.00
 3268.00       14  15  15  16  16  17  17  15  14  14  14  14  13  13  13  13   9   9   7   5   5   5   5   5   5    3268.00
 3267.00       14  14  15  15  16  17  17  15  15  15  14  14  13  13  13  13  11   8   5   5   5   5   5   5   4    3267.00
 3266.00       13  14  14  15  16  17  17  17  16  15  14  14  13  13  13  11  10  10   5   5   5   5   5   5   4    3266.00
 3265.00       13  14  14  15  15  17  17  17  16  15  15  15  14  14  13  11  10  10   5   5   5   5   5   4   4    3265.00
 3264.00       13  13  14  15  15  16  17  17  16  15  15  15  14  14  14  11  10  10   8   5   5   5   5   4   4    3264.00
 3263.00       13  13  13  15  15  16  17  18  16  15  16  15  15  14  14  11  10  10   8   7   5   5   5   4   4    3263.00
 3262.00       13  13  13  15  15  15  16  18  17  16  16  16  16  15  14  12  11   9   9   7   5   5   5   4   4    3262.00
 3261.00       13  13  13  13  15  15  16  17  19  18  16  16  16  15  12  11  11   8   8   7   7   5   4   4   4    3261.00
 3260.00       13  13  13  13  14  16  16  17  17  18  17  17  17  16  12  11  11   9   9   7   7   7   4   4   4    3260.00
 3259.00       12  12  13  13  14  16  16  17  18  19  18  18  18  16  13  12  12   8   8   7   7   6   4   4   4    3259.00
 3258.00       12  12  12  13  14  14  17  17  19  18  19  19  19  17  13  12  12   9   7   7   6   6   6   4   4    3258.00
 3257.00       12  12  12  13  13  14  15  18  18  19  17  20  20  20  14  13   9   8   7   7   6   6   6   6   4    3257.00
 3256.00       11  12  12  13  13  14  15  19  19  20  21  22  21  17  14  14   9   9   7   6   6   6   6   5   4    3256.00
 3255.00       11  11  12  13  13  14  15  15  20  21  22  20  23  18  15  15   8   8   7   7   6   6   5   5   5    3255.00
 3254.00       11  11  12  12  14  14  15  16  17  23  23  22  22  20  16  15   9   9   7   7   6   5   5   5   5    3254.00
 3253.00       10  11  12  12  13  14  15  16  17  23  24  22  24  21  18  16  10   8   7   6   6   5   5   5   5    3253.00
 3252.00       10  10  11  11  12  13  15  17  19  19  26  24  25  17  20  12   9   8   6   6   6   5   5   5   5    3252.00
 3251.00        9  10  11  11  12  13  14  15  16  19  21  29  17  15  12   9   8   7   6   6   6   6   6   5   5    3251.00
 3250.00        9  10  10  10  11  12  13  15  17  19  22  29  19  15   7   6   9   8   7   6   6   6   6   5   5    3250.00
             300.00  302.00  304.00  306.00  308.00  310.00  312.00  314.00  316.00  318.00  320.00  322.00  324.00
```

```
SECTION 1 OF 1   RUN NUMBER 1, POLLUTANT 2 (PARTICULATE ) ,UNCALIBRATED CONCENTRATIONS IN UG/M3                      TCM-2  RURAL
                        EXAMPLE OF POINT SOURCES RUN ON TCM2

                          METEOROLOGY:    HOUSTON HOBBY AIRPORT,1961-1969


              300.00   302.00   304.00   306.00   308.00   310.00   312.00   314.00   316.00   318.00   320.00   322.00   324.00

   3274.00     3   5   5   5   5   5   4   4   4   4   4   4   3   3   3   2   2   2   2   2   1   1   1   1   1     3274.00
   3273.00     3   4   5   5   5   5   4   4   4   4   4   4   4   3   3   2   2   2   2   2   1   1   1   1   1     3273.00
   3272.00     3   4   4   4   4   4   4   4   4   4   4   4   4   3   3   2   2   2   2   1   1   1   1   1   1     3272.00
   3271.00     4   4   4   4   4   4   4   4   4   4   4   4   3   3   3   3   2   2   2   1   1   1   1   1   1     3271.00
   3270.00     4   4   4   4   4   4   4   4   4   4   4   3   3   3   3   3   3   2   2   1   1   1   1   1   1     3270.00
   3269.00     4   4   4   4   4   4   4   4   4   4   4   3   3   3   3   3   3   3   2   1   1   1   1   1   1     3269.00
   3268.00     4   4   4   4   4   4   4   4   4   4   4   4   3   3   3   3   3   3   3   1   1   1   1   1   1     3268.00
   3267.00     3   3   4   4   4   4   4   4   4   4   4   4   3   3   3   3   3   3   1   1   1   1   1   1   1     3267.00
   3266.00     3   3   3   4   4   4   4   4   4   4   4   4   3   3   3   3   3   3   1   1   1   1   1   1   1     3266.00
   3265.00     3   3   3   3   3   4   4   4   4   4   4   4   3   3   3   3   3   3   1   1   1   1   1   1   1     3265.00
   3264.00     3   3   3   3   3   3   4   4   4   4   4   4   3   3   3   3   3   3   2   1   1   1   1   1   1     3264.00
   3263.00     3   3   3   3   3   3   4   4   4   4   4   4   4   4   4   4   3   3   2   2   1   1   1   1   1     3263.00
   3262.00     3   3   3   3   3   3   3   4   4   4   4   4   4   4   4   4   4   2   2   2   1   1   1   1   1     3262.00
   3261.00     3   3   3   3   3   3   3   4   4   4   4   4   4   4   4   4   4   2   2   2   2   1   1   1   1     3261.00
   3260.00     3   3   3   3   3   3   4   4   4   4   4   4   4   4   4   4   4   2   2   2   2   2   1   1   1     3260.00
   3259.00     3   3   3   3   3   3   4   4   4   4   5   5   5   4   4   4   4   2   2   2   2   2   1   1   1     3259.00
   3258.00     3   3   3   3   3   3   4   4   4   3   5   5   5   4   4   4   4   2   2   2   2   2   2   1   1     3258.00
   3257.00     3   3   3   3   3   3   4   4   4   3   4   5   5   5   4   4   2   2   2   2   2   2   2   2   1     3257.00
   3256.00     3   3   3   3   3   3   4   4   4   4   4   5   5   6   5   5   2   2   2   2   2   2   2   2   1     3256.00
   3255.00     3   3   3   3   3   3   3   3   4   4   4   4   5   6   5   5   2   2   2   2   2   2   1   1   1     3255.00
   3254.00     3   3   3   3   3   3   3   3   3   4   4   4   4   7   6   6   3   3   2   2   2   2   1   1   1     3254.00
   3253.00     2   3   3   3   3   3   3   3   3   4   4   4   4   7   6   5   3   2   2   2   2   2   1   1   1     3253.00
   3252.00     2   2   2   2   3   3   3   3   4   4   4   4   5   5   8   4   3   2   2   2   2   1   1   1   1     3252.00
   3251.00     2   2   2   2   3   3   3   3   3   3   3   4   4   5   3   3   2   2   2   2   2   2   2   1   1     3251.00
   3250.00     2   2   2   2   2   3   3   3   3   3   3   3   4   4   1   1   3   2   2   2   2   2   2   1   1     3250.00

              300.00   302.00   304.00   306.00   308.00   310.00   312.00   314.00   316.00   318.00   320.00   322.00   324.00
```

```
SECTION 1 OF 1    RUN NUMBER 1, POLLUTANT 2 (PARTICULATE ) ,CALIBRATED CONCENTRATIONS (PERCENT NAAQS            ) TCM-2  RURAL
                    EXAMPLE OF POINT SOURCES RUN ON TCM2

                    METEOROLOGY:    HOUSTON HOBBY AIRPORT,1951-1969

              300.00  302.00  304.00  306.00  308.00  310.00  312.00  314.00  316.00  318.00  320.00  322.00  324.00
   3274.00      4   5   6   5   6   5   6   5   5   5   5   5   3   3   3   3   3   3   3   3   2   2   2   1   1    3274.00
   3273.00      4   6   6   6   6   6   5   5   5   5   5   5   5   3   3   3   3   3   3   3   2   2   2   2   1    3273.00
   3272.00      4   6   5   5   6   5   5   5   5   5   5   5   5   3   3   3   3   3   3   2   2   2   2   2   2    3272.00
   3271.00      5   6   6   6   6   6   6   5   5   5   5   5   5   5   3   3   3   3   3   2   2   2   2   2   2    3271.00
   3270.00      5   5   6   6   6   5   5   5   5   5   5   5   5   5   4   3   3   3   3   2   2   2   2   2   2    3270.00
   3269.00      5   5   5   6   6   6   6   5   5   5   5   5   5   5   4   3   3   3   3   2   2   2   2   2   2    3269.00
   3268.00      5   5   5   6   6   6   5   5   5   5   5   5   5   5   4   4   3   3   3   2   2   2   2   2   2    3268.00
   3267.00      5   5   5   5   6   6   6   5   5   5   5   3   5   5   5   4   4   3   2   2   2   2   2   2   2    3267.00
   3266.00      5   5   5   5   6   6   5   6   5   5   5   5   5   5   5   4   4   4   2   2   2   2   2   2   2    3266.00
   3265.00      4   5   5   5   5   6   6   6   5   5   5   5   5   5   5   5   5   4   2   2   2   2   2   2   2    3265.00
   3264.00      4   4   5   5   5   5   6   6   5   5   5   5   5   5   5   5   5   5   3   2   2   2   2   2   1    3264.00
   3263.00      4   4   4   5   5   5   6   6   5   5   5   5   5   5   5   5   5   5   3   3   2   2   2   2   1    3263.00
   3262.00      4   4   4   4   5   5   5   5   5   5   5   6   6   5   5   5   5   3   3   3   2   2   2   1   1    3262.00
   3261.00      4   4   4   4   5   5   5   5   6   6   6   6   6   5   5   5   5   3   3   3   3   2   1   1   1    3261.00
   3260.00      4   4   4   4   5   5   5   5   5   6   6   5   5   5   5   5   5   3   3   3   3   3   1   1   1    3260.00
   3259.00      4   4   4   4   5   5   5   5   5   6   6   6   6   5   5   5   5   3   3   3   3   2   1   1   1    3259.00
   3258.00      4   4   4   4   5   5   5   5   5   5   5   5   7   5   6   6   5   3   3   3   2   2   2   1   1    3258.00
   3257.00      4   4   4   4   4   5   5   5   5   5   5   7   7   7   6   6   3   3   3   3   2   2   2   2   1    3257.00
   3256.00      4   4   4   4   4   4   5   5   5   5   5   7   7   8   6   6   3   3   3   2   2   2   2   2   1    3256.00
   3255.00      4   4   4   4   4   4   4   4   5   5   5   5   9   8   7   7   3   3   2   2   2   2   2   2   2    3255.00
   3254.00      4   4   4   4   4   4   4   4   5   5   5   5   6   7   7   7   4   3   3   2   2   2   2   2   2    3254.00
   3253.00      3   4   4   4   4   4   4   4   5   5   5   6   5   9   8   8   4   3   3   2   2   2   2   2   2    3253.00
   3252.00      3   3   3   3   3   4   4   4   5   5   5   5   5   7  10   5   4   3   2   2   2   2   2   2   2    3252.00
   3251.00      3   3   3   3   3   3   4   4   4   4   5   5   6   7   5   3   3   3   2   2   2   2   2   2   2    3251.00
   3250.00      3   3   3   3   3   3   4   4   4   4   5   4   5   6   2   2   4   3   3   2   2   2   2   2   2    3250.00
              300.00  302.00  304.00  306.00  308.00  310.00  312.00  314.00  316.00  318.00  320.00  322.00  324.00
```

```
                T E X A S   C L I M A T O L O G I C A L   M O D E L  -  V E R S I O N - 2  ( R U R A L )

                      HIGHEST PREDICTED CONCENTRATIONS FOR EACH POLLUTANT FOR EACH SCENARIO

                       EXAMPLE OF POINT SOURCES RUN ON TCM2

--------------------------------------------------------------------------------------------------------------

  RUN        METEOROLOGY
 NUMBER

   1         HOUSTON HOBBY AIRPORT,1961-1969


--------------------------------------------------------------------------------------------------------------

UNCALIBRATED CONCENTRATIONS IN MICROGRAMS  PER CUBIC METER

  RUN       POLLUTANT 1 CALIBRATION                                    POLLUTANT 2 CALIBRATION
 NUMBER        A 1         B 1                                            A 2       B 2

   1        0.0000      1.2500     PERCENT NAAQS                       0.0000     1.3333     PERCENT NAAQS

CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC

--------------------------------------------------------------------------------------------------------------

              RECEPTOR COORDINATES     POLLUTANT 1 (SO2          )    RECEPTOR COORDINATES     POLLUTANT 2 (PARTICULATE )
   RUN                                UNCALIBRATED   CALIBRATED                                UNCALIBRATED   CALIBRATED
  NUMBER       X (KM)    Y (KM)       CONCENTRATION  CONCENTRATION    X (KM)    Y (KM)         CONCENTRATION  CONCENTRATION

    1         311.000  3251.000         23.5963        29.4954       314.000  3252.000           7.8618        10.4822
```

APPENDIX H

TCM-2 PROGRAM LISTING

```
$SET LINEINFO OWN STACK OPT=-1 $
FILE     1 (KIND=PUNCH)
FILE     4 (KIND=DISK)
FILE     5 (KIND=READER)
FILE     6 (KIND=PRINTER)
FILE     8 (KIND=DISK)
C
C     ////////////////////////////////////////////////////////////////
C     /                                                              /
C     /   T E X A S   C L I M A T O L O G I C A L   M O D E L        /
C     /                                                              /
C     /                        VERSION 2                             /
C     /                                                              /
C     /                DEVELOPED BY THE STAFF                        /
C     /                                                              /
C     /                         OF THE                               /
C     /                                                              /
C     /                TEXAS AIR CONTROL BOARD                       /
C     /                                                              /
C     /  PUBLISHED MARCH, 1975 AS THE "FAST AIR QUALITY MODEL"       /
C     /                                                              /
C     /          REVISED:  MAY, 1976 AND JUN, 1980                   /
C     /                                                              /
C     ////////////////////////////////////////////////////////////////
C
      COMMON/FAQMS/WR(16,6,5),KPS(20,19,6),CPS(50,50,2),THETA(8),
     1XSWC,YSWC,LX,LY,GRID,IRD,IWR,IPU,NWORST(25,25,5),CWORST(25,25,5),
     2IPT,XSWR,YSWR
      DIMENSION G(50,50,2),GL(50,50,2),PCLNAM(3,2),CALNAM(5,7,2)
      DIMENSION CR(100,2),JSUM(100,2),CSUM(100,2),XR(100),YR(100),CF(2)
      DIMENSION CRR(2),CORREL(2),STDERR(2),CCALIB(2)
      DIMENSION A(20,3),B(20,3)
      DIMENSION E(2),F(20),TT(20),HLIM(19),DLIM(20),TN(5,20)
      DIMENSION HALF(2),DECAY(20,2),ASCALE(5,2)
      DIMENSION WIND(6),WRTEMP(3),P(6),UC(6),WSUM(6)
      DIMENSION UMEAN(5),U(6,5),AN(5,2),BN(5,2),TA(5)
      DIMENSION HH(6),VUE(6),FREQ(6),KAY(6),NSH(6),FSH(6),SIO(2)
      DIMENSION C1(2),C2(2),C3(2),C4(2),Q1(2),Q2(2),Q3(2),Q4(2),
     1 CA(2),CB(2),QA(2),QB(2),QN(4),AAR(6),BAR(6),PEAK(6),
     2 ESH(6),ESHH(6),FSHH(6),NSHH(6),SUMAQ(2),SUMPQ(2),IBUDY(6)
      REAL KAY,KPS
      DATA(KPS(I, 1,1),I=1,20)/    3.2219,    1.5296,     .8399,     .4372,
     1                              .2552,     .0902,     .0340,     .0140,
     2                              .0063,     .0029,     .0015,     .0008,
     3                              .0004,     .0002,     .0001,     .0001,
     4                              .0000,     .0000,     .0000,     .0000/
      DATA(KPS(I, 2,1),I=1,20)/    3.2213,    1.5297,     .8398,     .4372,
     1                              .2552,     .0902,     .0340,     .0140,
     2                              .0063,     .0029,     .0015,     .0009,
     3                              .0004,     .0002,     .0001,     .0001,
     4                              .0000,     .0000,     .0000,     .0000/
      DATA(KPS(I, 3,1),I=1,20)/    3.2205,    1.5295,     .8397,     .4372,
     1                              .2552,     .0902,     .0340,     .0140,
     2                              .0063,     .0029,     .0015,     .0008,
     3                              .0004,     .0002,     .0001,     .0001,
     4                              .0000,     .0000,     .0000,     .0000/
      DATA(KPS(I, 4,1),I=1,20)/    3.2194,    1.5293,     .8397,     .4372,
     1                              .2552,     .0902,     .0340,     .0140,
     2                              .0063,     .0029,     .0015,     .0009,
     3                              .0004,     .0002,     .0001,     .0001,
     4                              .0000,     .0000,     .0000,     .0000/
```

```
 DATA(KPS(I, 5,1),I=1,20)/   3.2190,   1.5291,   .8396,   .4372,        00000710
1                             .2551,    .0902,   .0340,   .0140,        00000720
2                             .0063,    .0029,   .0015,   .0008,        00000730
3                             .0004,    .0002,   .0001,   .0001,        00000740
4                             .0000,    .0000,   .0000,   .0000/        00000750
 DATA(KPS(I, 6,1),I=1,20)/   3.2164,   1.5288,   .8396,   .4372,        00000760
1                             .2551,    .0902,   .0340,   .0140,        00000770
2                             .0063,    .0029,   .0015,   .0008,        00000780
3                             .0004,    .0002,   .0001,   .0001,        00000790
4                             .0000,    .0000,   .0000,   .0000/        00000800
 DATA(KPS(I, 7,1),I=1,20)/   3.2146,   1.5285,   .8395,   .4372,        00000810
1                             .2551,    .0902,   .0340,   .0140,        00000820
2                             .0063,    .0029,   .0015,   .0008,        00000830
3                             .0004,    .0002,   .0001,   .0001,        00000840
4                             .0000,    .0000,   .0000,   .0000/        00000850
 DATA(KPS(I, 8,1),I=1,20)/   3.2125,   1.5282,   .8394,   .4371,        00000860
1                             .2551,    .0902,   .0340,   .0140,        00000870
2                             .0063,    .0029,   .0015,   .0008,        00000880
3                             .0004,    .0002,   .0001,   .0001,        00000890
4                             .0000,    .0000,   .0000,   .0000/        00000900
 DATA(KPS(I, 9,1),I=1,20)/   3.2102,   1.5278,   .8393,   .4371,        00000910
1                             .2551,    .0902,   .0340,   .0140,        00000920
2                             .0063,    .0029,   .0015,   .0008,        00000930
3                             .0004,    .0002,   .0001,   .0001,        00000940
4                             .0000,    .0000,   .0000,   .0000/        00000950
 DATA(KPS(I,10,1),I=1,20)/   3.1995,   1.5257,   .8389,   .4370,        00000960
1                             .2551,    .0902,   .0340,   .0140,        00000970
2                             .0063,    .0029,   .0015,   .0008,        00000980
3                             .0004,    .0002,   .0001,   .0001,        00000990
4                             .0000,    .0000,   .0000,   .0000/        00001000
 DATA(KPS(I,11,1),I=1,20)/   3.1738,   1.5214,   .8378,   .4368,        00001010
1                             .2550,    .0902,   .0340,   .0140,        00001020
2                             .0063,    .0029,   .0015,   .0008,        00001030
3                             .0004,    .0002,   .0001,   .0001,        00001040
4                             .0000,    .0000,   .0000,   .0000/        00001050
 DATA(KPS(I,12,1),I=1,20)/   3.1140,   1.5109,   .8352,   .4362,        00001060
1                             .2549,    .0902,   .0340,   .0140,        00001070
2                             .0063,    .0029,   .0015,   .0008,        00001080
3                             .0004,    .0002,   .0001,   .0001,        00001090
4                             .0000,    .0000,   .0000,   .0000/        00001100
 DATA(KPS(I,13,1),I=1,20)/   3.0321,   1.4963,   .8316,   .4354,        00001110
1                             .2547,    .0902,   .0340,   .0140,        00001120
2                             .0063,    .0029,   .0015,   .0008,        00001130
3                             .0004,    .0002,   .0001,   .0001,        00001140
4                             .0000,    .0000,   .0000,   .0000/        00001150
 DATA(KPS(I,14,1),I=1,20)/   2.8100,   1.4553,   .8214,   .4332,        00001160
1                             .2540,    .0901,   .0340,   .0140,        00001170
2                             .0063,    .0029,   .0015,   .0008,        00001180
3                             .0004,    .0002,   .0001,   .0001,        00001190
4                             .0000,    .0000,   .0000,   .0000/        00001200
 DATA(KPS(I,15,1),I=1,20)/   2.3678,   1.3671,   .7989,   .4283,        00001210
1                             .2526,    .0900,   .0340,   .0140,        00001220
2                             .0063,    .0029,   .0015,   .0008,        00001230
3                             .0004,    .0002,   .0001,   .0001,        00001240
4                             .0000,    .0000,   .0000,   .0000/        00001250
 DATA(KPS(I,16,1),I=1,20)/   1.5287,   1.1652,   .7441,   .4159,        00001260
1                             .2491,    .0897,   .0340,   .0140,        00001270
2                             .0063,    .0029,   .0015,   .0008,        00001280
3                             .0004,    .0002,   .0001,   .0001,        00001290
4                             .0000,    .0000,   .0000,   .0000/        00001300
 DATA(KPS(I,17,1),I=1,20)/    .7035,    .8777,   .6561,   .3948,        00001310
1                             .2429,    .0892,   .0339,   .0140,        00001320
2                             .0063,    .0029,   .0015,   .0008,        00001330
3                             .0004,    .0002,   .0001,   .0001,        00001340
```

```
4                                .0000,     .0000,     .0000,     .0000/         00001350
 DATA(KPS(I,18,1),I=1,20)/       .1632,     .5149,     .5177,     .3579,         00001360
1                                .2317,     .0881,     .0338,     .0140,         00001370
2                                .0063,     .0029,     .0015,     .0008,         00001380
3                                .0004,     .0002,     .0001,     .0001,         00001390
4                                .0000,     .0000,     .0000,     .0000/         00001400
 DATA(KPS(I,19,1),I=1,20)/       .0073,     .1657,     .3128,     .2906,         00001410
1                                .2095,     .0460,     .0336,     .0139,         00001420
2                                .0063,     .0029,     .0015,     .0008,         00001430
3                                .0004,     .0002,     .0001,     .0001,         00001440
4                                .0000,     .0000,     .0000,     .0000/         00001450
 DATA(KPS(I, 1,2),I=1,20)/     15.2461,    9.1700,    6.0872,    3.8961,         00001460
1                               2.6957,    1.3240,     .6791,     .3697,         00001470
2                                .2134,     .1272,     .0788,     .0506,         00001480
3                                .0332,     .0224,     .0155,     .0109,         00001490
4                                .0078,     .0057,     .0042,     .0031/         00001500
 DATA(KPS(I, 2,2),I=1,20)/     15.1809,    9.1470,    6.0773,    3.8921,         00001510
1                               2.6936,    1.3235,     .6790,     .3697,         00001520
2                                .2134,     .1272,     .0788,     .0506,         00001530
3                                .0332,     .0224,     .0155,     .0109,         00001540
4                                .0078,     .0057,     .0042,     .0031/         00001550
 DATA(KPS(I, 3,2),I=1,20)/     15.0900,    9.1150,    6.0535,    3.8866,         00001560
1                               2.6912,    1.3229,     .6789,     .3696,         00001570
2                                .2134,     .1272,     .0788,     .0506,         00001580
3                                .0332,     .0224,     .0155,     .0109,         00001590
4                                .0078,     .0057,     .0042,     .0031/         00001600
 DATA(KPS(I, 4,2),I=1,20)/     14.9740,    9.0740,    6.0458,    3.8795,         00001610
1                               2.6879,    1.3222,     .6787,     .3696,         00001620
2                                .2134,     .1272,     .0788,     .0506,         00001630
3                                .0332,     .0224,     .0155,     .0109,         00001640
4                                .0078,     .0057,     .0042,     .0031/         00001650
 DATA(KPS(I, 5,2),I=1,20)/     14.8335,    9.0241,    6.0242,    3.8709,         00001660
1                               2.6836,    1.3212,     .6784,     .3695,         00001670
2                                .2133,     .1272,     .0788,     .0506,         00001680
3                                .0332,     .0224,     .0155,     .0109,         00001690
4                                .0078,     .0057,     .0042,     .0031/         00001700
 DATA(KPS(I, 6,2),I=1,20)/     14.6690,    8.9655,    5.9988,    3.8607,         00001710
1                               2.6790,    1.3201,     .6781,     .3694,         00001720
2                                .2133,     .1272,     .0788,     .0506,         00001730
3                                .0332,     .0224,     .0155,     .0109,         00001740
4                                .0078,     .0057,     .0042,     .0031/         00001750
 DATA(KPS(I, 7,2),I=1,20)/     14.4816,    8.8984,    5.9696,    3.8489,         00001760
1                               2.6735,    1.3188,     .6778,     .3693,         00001770
2                                .2133,     .1272,     .0787,     .0506,         00001780
3                                .0332,     .0224,     .0155,     .0109,         00001790
4                                .0078,     .0057,     .0042,     .0031/         00001800
 DATA(KPS(I, 8,2),I=1,20)/     14.2720,    8.8229,    5.9367,    3.8357,         00001810
1                               2.6673,    1.3174,     .6774,     .3692,         00001820
2                                .2132,     .1272,     .0787,     .0506,         00001830
3                                .0332,     .0224,     .0155,     .0109,         00001840
4                                .0078,     .0057,     .0042,     .0031/         00001850
 DATA(KPS(I, 9,2),I=1,20)/     14.0413,    8.7393,    5.9002,    3.8209,         00001860
1                               2.6603,    1.3157,     .6770,     .3691,         00001870
2                                .2132,     .1272,     .0787,     .0506,         00001880
3                                .0332,     .0224,     .0155,     .0109,         00001890
4                                .0078,     .0057,     .0042,     .0031/         00001900
 DATA(KPS(I,10,2),I=1,20)/     12.9318,    8.3289,    5.7189,    3.7471,         00001910
1                               2.6254,    1.3075,     .6749,     .3685,         00001920
2                                .2130,     .1271,     .0787,     .0506,         00001930
3                                .0332,     .0224,     .0155,     .0109,         00001940
4                                .0078,     .0057,     .0042,     .0031/         00001950
 DATA(KPS(I,11,2),I=1,20)/     10.8564,    7.5196,    5.3519,    3.5951,         00001960
1                               2.5527,    1.2903,     .6705,     .3672,         00001970
2                                .2126,     .1270,     .0787,     .0505,         00001980
```

```
     3                          .0332,    .0224,    .0155,    .0109,        00001990
     4                          .0078,    .0057,    .0042,    .0031/        00002000
      DATA(KPS(I,12,2),I=1,20)/ 7.0710,   5.8532,   4.5490,   3.2491,       00002010
     1                          2.3929,   1.2490,    .6598,    .3641,       00002020
     2                           .2116,    .1266,    .0785,    .0505,       00002030
     3                           .0332,    .0224,    .0155,    .0109,       00002040
     4                           .0078,    .0057,    .0042,    .0031/       00002050
      DATA(KPS(I,13,2),I=1,20)/ 3.8797,   4.1217,   3.6231,   2.8178,       00002060
     1                          2.1639,   1.1934,    .6451,    .3598,       00002070
     2                           .2102,    .1261,    .0783,    .0504,       00002080
     3                           .0332,    .0224,    .0155,    .0109,       00002090
     4                           .0078,    .0057,    .0042,    .0031/       00002100
      DATA(KPS(I,14,2),I=1,20)/  .6932,   1.5131,   1.8911,   1.8774,       00002110
     1                          1.6431,   1.0478,    .6049,    .3478,       00002120
     2                           .2062,    .1248,    .0778,    .0502,       00002130
     3                           .0331,    .0223,    .0155,    .0109,       00002140
     4                           .0078,    .0057,    .0042,    .0031/       00002150
      DATA(KPS(I,15,2),I=1,20)/  .0147,    .1587,    .4379,    .7530,       00002160
     1                           .8843,    .7819,    .5233,    .3223,       00002170
     2                           .1976,    .1217,    .0767,    .0497,       00002180
     3                           .0329,    .0223,    .0154,    .0109,       00002190
     4                           .0078,    .0057,    .0042,    .0031/       00002200
      DATA(KPS(I,16,2),I=1,20)/  .0000,    .0005,    .0104,    .0729,       00002210
     1                           .1916,    .3700,    .3614,    .2652,       00002220
     2                           .1772,    .1142,    .0738,    .0486,       00002230
     3                           .0324,    .0220,    .0153,    .0108,       00002240
     4                           .0078,    .0057,    .0042,    .0031/       00002250
      DATA(KPS(I,17,2),I=1,20)/  .0000,    .0000,    .0000,    .0012,       00002260
     1                           .0109,    .0982,    .1675,    .1877,       00002270
     2                           .1459,    .1021,    .0690,    .0465,       00002280
     3                           .0315,    .0216,    .0151,    .0107,       00002290
     4                           .0077,    .0056,    .0042,    .0031/       00002300
      DATA(KPS(I,18,2),I=1,20)/  .0000,    .0000,    .0000,    .0000,       00002310
     1                           .0001,    .0081,    .0545,    .0979,       00002320
     2                           .1013,    .0826,    .0607,    .0430,       00002330
     3                           .0299,    .0209,    .0148,    .0105,       00002340
     4                           .0076,    .0056,    .0042,    .0031/       00002350
      DATA(KPS(I,19,2),I=1,20)/  .0000,    .0000,    .0000,    .0000,       00002360
     1                           .0000,    .0000,    .0039,    .0245,       00002370
     2                           .0467,    .0527,    .0463,    .0362,       00002380
     3                           .0268,    .0195,    .0141,    .0102,       00002390
     4                           .0074,    .0055,    .0041,    .0031/       00002400
      DATA(KPS(I, 1,3),I=1,20)/ 27.4916,  17.348.,  11.9619,   7.9756,      00002410
     1                          5.7060,   2.9881,   1.6272,    .9381,       00002420
     2                           .5709,    .3578,    .2319,    .1554,       00002430
     3                           .1064,    .0745,    .0533,    .0388,       00002440
     4                           .0287,    .0216,    .0164,    .0126/       00002450
      DATA(KPS(I, 2,3),I=1,20)/ 27.1049,  17.1916,  11.8865,   7.9415,      00002460
     1                          5.6894,   2.9831,   1.6257,    .9376,       00002470
     2                           .5707,    .3577,    .2319,    .1554,       00002480
     3                           .1064,    .0745,    .0533,    .0388,       00002490
     4                           .0287,    .0216,    .0164,    .0126/       00002500
      DATA(KPS(I, 3,3),I=1,20)/ 26.5728,  16.9749,  11.7817,   7.8941,      00002510
     1                          5.6638,   2.9762,   1.6236,    .9369,       00002520
     2                           .5705,    .3576,    .2318,    .1554,       00002530
     3                           .1064,    .0745,    .0533,    .0388,       00002540
     4                           .0287,    .0216,    .0164,    .0126/       00002550
      DATA(KPS(I, 4,3),I=1,20)/ 25.9040,  16.7003,  11.6484,   7.8336,      00002560
     1                          5.6323,   2.9673,   1.6209,    .9360,       00002570
     2                           .5701,    .3575,    .2318,    .1554,       00002580
     3                           .1063,    .0745,    .0533,    .0388,       00002590
     4                           .0287,    .0216,    .0164,    .0126/       00002600
      DATA(KPS(I, 5,3),I=1,20)/ 25.1093,  16.3707,  11.4874,   7.7603,      00002610
     1                          5.5941,   2.9565,   1.6176,    .9348,       00002620
     2                            .5697,    .3573,    .2317,    .1553,           00002630
     3                            .1063,    .0745,    .0533,    .0388,           00002640
     4                            .0287,    .0216,    .0164,    .0126/           00002650
      DATA(KPS(I, 6,3),I=1,20)/ 24.2015,  15.9395,  11.3001,   7.6745,           00002660
     1                           5.5492,   2.9437,   1.6137,    .9335,           00002670
     2                            .5692,    .3571,    .2316,    .1553,           00002680
     3                            .1063,    .0745,    .0533,    .0388,           00002690
     4                            .0287,    .0216,    .0164,    .0126/           00002700
      DATA(KPS(I, 7,3),I=1,20)/ 23.1948,  15.5607,  11.0877,   7.5766,           00002710
     1                           5.4979,   2.9291,   1.6093,    .9320,           00002720
     2                            .5686,    .3569,    .2315,    .1552,           00002730
     3                            .1063,    .0744,    .0533,    .0388,           00002740
     4                            .0287,    .0216,    .0164,    .0126/           00002750
      DATA(KPS(I, 8,3),I=1,20)/ 22.1043,  15.0987,  10.8518,   7.4673,           00002760
     1                           5.4403,   2.9126,   1.6042,    .9303,           00002770
     2                            .5680,    .3566,    .2314,    .1552,           00002780
     3                            .1063,    .0744,    .0533,    .0388,           00002790
     4                            .0287,    .0216,    .0164,    .0126/           00002800
      DATA(KPS(I, 9,3),I=1,20)/ 20.9462,  14.5780,  10.5941,   7.3469,           00002810
     1                           5.3767,   2.8943,   1.5986,    .9285,           00002820
     2                            .5672,    .3563,    .2313,    .1551,           00002830
     3                            .1062,    .0744,    .0533,    .0388,           00002840
     4                            .0287,    .0216,    .0164,    .0126/           00002850
      DATA(KPS(I,10,3),I=1,20)/ 15.9592,  12.2502,   9.3925,   6.7678,           00002860
     1                           5.0664,   2.8035,   1.5704,    .9186,           00002870
     2                            .5635,    .3548,    .2306,    .1548,           00002880
     3                            .1061,    .0743,    .0533,    .0388,           00002890
     4                            .0287,    .0216,    .0164,    .0126/           00002900
      DATA(KPS(I,11,3),I=1,20)/  8.9549,   8.4643,   7.2488,   5.6843,           00002910
     1                           4.4652,   2.6199,   1.5123,    .8984,           00002920
     2                            .5558,    .3517,    .2293,    .1542,           00002930
     3                            .1053,    .0742,    .0532,    .0387,           00002940
     4                            .0287,    .0215,    .0164,    .0126/           00002950
      DATA(KPS(I,12,3),I=1,20)/  2.1726,   3.4204,   3.8513,   3.7065,           00002960
     1                           3.2762,   2.2191,   1.3787,    .8506,           00002970
     2                            .5372,    .3441,    .2260,    .1527,           00002980
     3                            .1051,    .0738,    .0530,    .0386,           00002990
     4                            .0286,    .0215,    .0164,    .0126/           00003000
      DATA(KPS(I,13,3),I=1,20)/   .2991,    .9620,   1.5280,   2.0369,           00003010
     1                           2.1239,   1.7568,   1.2112,    .7880,           00003020
     2                            .5122,    .3335,    .2215,    .1506,           00003030
     3                            .1041,    .0733,    .0527,    .0385,           00003040
     4                            .0285,    .0215,    .0163,    .0125/           00003050
      DATA(KPS(I,14,3),I=1,20)/   .0010,    .0257,    .1266,    .3682,           00003060
     1                            .6156,    .9053,    .8366,    .6334,           00003070
     2                            .4470,    .3059,    .2091,    .1448,           00003080
     3                            .1013,    .0719,    .0520,    .0381,           00003090
     4                            .0283,    .0213,    .0163,    .0125/           00003100
      DATA(KPS(I,15,3),I=1,20)/   .0000,    .0000,    .0004,    .0078,           00003110
     1                            .0379,    .2032,    .3639,    .3874,           00003120
     2                            .3291,    .2514,    .1837,    .1325,           00003130
     3                            .0952,    .0688,    .0504,    .0372,           00003140
     4                            .0278,    .0211,    .0161,    .0124/           00003150
      DATA(KPS(I,16,3),I=1,20)/   .0000,    .0000,    .0000,    .0000,           00003160
     1                            .0000,    .0045,    .0434,    .1103,           00003170
     2                            .1505,    .1523,    .1319,    .1057,           00003180
     3                            .0813,    .0615,    .0464,    .0350,           00003190
     4                            .0266,    .0203,    .0157,    .0122/           00003200
      DATA(KPS(I,17,3),I=1,20)/   .0000,    .0000,    .0000,    .0000,           00003210
     1                            .0000,    .0000,    .0010,    .0119,           00003220
     2                            .0376,    .0626,    .0732,    .0706,           00003230
     3                            .0615,    .0504,    .0402,    .0315,           00003240
     4                            .0245,    .0191,    .0150,    .0118/           00003250
      DATA(KPS(I,18,3),I=1,20)/   .0000,    .0000,    .0000,    .0000,           00003260
     1                              .0000,    .0000,    .0000,    .0002,        00003270
     2                              .0023,    .0118,    .0242,    .0332,        00003280
     3                              .0363,    .0347,    .0306,    .0257,        00003290
     4                              .0211,    .0171,    .0137,    .0110/        00003300
      DATA(KPS(I,19,3),I=1,20)/     .0000,    .0000,    .0000,    .0000,        00003310
     1                              .0000,    .0000,    .0000,    .0000,        00003320
     2                              .0000,    .0003,    .0023,    .0067,        00003330
     3                              .0119,    .0156,    .0171,    .0168,        00003340
     4                              .0153,    .0134,    .0113,    .0095/        00003350
      DATA(KPS(I, 1,4),I=1,20)/   55.2626,  37.3082,  27.1125,  19.1133,        00003360
     1                            14.3048,   8.1574,   4.8050,   3.0540,        00003370
     2                             2.0361,   1.3900,    .9752,    .7030,        00003380
     3                              .5156,    .3852,    .2932,    .2260,        00003390
     4                              .1765,    .1397,    .1117,    .0902/        00003400
      DATA(KPS(I, 2,4),I=1,20)/   51.9530,  35.6901,  26.2073,  18.6339,        00003410
     1                            14.0217,   8.0553,   4.7659,   3.0363,        00003420
     2                             2.0272,   1.3854,    .9728,    .7016,        00003430
     3                              .5148,    .3847,    .2929,    .2258,        00003440
     4                              .1764,    .1397,    .1116,    .0901/        00003450
      DATA(KPS(I, 3,4),I=1,20)/   47.6499,  33.5420,  24.9905,  17.9828,        00003460
     1                            13.6347,   7.9145,   4.7113,   3.0116,        00003470
     2                             2.0149,   1.3790,    .9693,    .6996,        00003480
     3                              .5136,    .3840,    .2924,    .2255,        00003490
     4                              .1762,    .1395,    .1116,    .0901/        00003500
      DATA(KPS(I, 4,4),I=1,20)/   42.6369,  30.9690,  23.5086,  17.1791,        00003510
     1                            13.1527,   7.7371,   4.6431,   2.9801,        00003520
     2                             1.9992,   1.3708,    .9648,    .6971,        00003530
     3                              .5121,    .3831,    .2919,    .2251,        00003540
     4                              .1760,    .1394,    .1115,    .0900/        00003550
      DATA(KPS(I, 5,4),I=1,20)/   37.2204,  28.0907,  21.8163,  16.2453,        00003560
     1                            12.5868,   7.5257,   4.5605,   2.9420,        00003570
     2                             1.9801,   1.3609,    .9594,    .6940,        00003580
     3                              .5103,    .3820,    .2912,    .2247,        00003590
     4                              .1757,    .1392,    .1113,    .0899/        00003600
      DATA(KPS(I, 6,4),I=1,20)/   31.6992,  25.0320,  19.9727,  15.2070,        00003610
     1                            11.9492,   7.2833,   4.4648,   2.8977,        00003620
     2                             1.9578,   1.3492,    .9531,    .6904,        00003630
     3                              .5081,    .3807,    .2904,    .2242,        00003640
     4                              .1754,    .1390,    .1112,    .0898/        00003650
      DATA(KPS(I, 7,4),I=1,20)/   26.3383,  21.9142,  18.0381,  14.0912,        00003660
     1                            11.2536,   7.0133,   4.3568,   2.8474,        00003670
     2                             1.9324,   1.3359,    .9458,    .6862,        00003680
     3                              .5057,    .3792,    .2894,    .2236,        00003690
     4                              .1750,    .1387,    .1110,    .0897/        00003700
      DATA(KPS(I, 8,4),I=1,20)/   21.3500,  18.8475,  16.9712,  12.9252,        00003710
     1                            10.5141,   6.7194,   4.2376,   2.7914,        00003720
     2                             1.9040,   1.3210,    .9376,    .6815,        00003730
     3                              .5029,    .3776,    .2884,    .2229,        00003740
     4                              .1745,    .1384,    .1108,    .0896/        00003750
      DATA(KPS(I, 9,4),I=1,20)/   16.8842,  15.9250,  14.1255,  11.7359,        00003760
     1                             9.7450,   6.4054,   4.1082,   2.7302,        00003770
     2                             1.8728,   1.3045,    .9285,    .6763,        00003780
     3                              .4999,    .3757,    .2872,    .2222,        00003790
     4                              .1740,    .1381,    .1106,    .0894/        00003800
      DATA(KPS(I,10,4),I=1,20)/    5.1586,   6.7975,   7.3593,   7.2060,        00003810
     1                             6.6386,   5.0298,   3.5125,   2.4407,        00003820
     2                             1.7226,   1.2243,    .8840,    .6506,        00003830
     3                              .4846,    .3664,    .2813,    .2134,        00003840
     4                              .1716,    .1364,    .1094,    .0886/        00003850
      DATA(KPS(I,11,4),I=1,20)/     .4152,   1.1135,   1.8413,   2.5561,        00003860
     1                             2.9365,   3.0090,   2.5179,   1.9234,        00003870
     2                             1.4422,   1.0699,    .7964,    .5991,        00003880
     3                              .4537,    .3473,    .2693,    .2106,        00003890
     4                              .1664,    .1330,    .1071,    .0870/        00003900
```

```
      DATA(KPS(I,12,4),I=1,20)/   .0009,   .0132,   .0617,   .2015,          00003910
     1                            .3977,   .8542,  1.1135,  1.0725,          00003920
     2                            .9331,   .7689,   .6167,   .4896,          00003930
     3                            .3661,   .3048,   .2419,   .1927,          00003940
     4                            .1545,   .1249,   .1015,   .0831/          00003950
      DATA(KPS(I,13,4),I=1,20)/   .0000,   .0000,   .0005,   .0058,          00003960
     1                            .0242,   .1465,   .3553,   .4737,          00003970
     2                            .5072,   .4842,   .4311,   .3690,          00003980
     3                            .3080,   .2538,   .2081,   .1701,          00003990
     4                            .1392,   .1143,   .0942,   .0779/          00004000
      DATA(KPS(I,14,4),I=1,20)/   .0000,   .0000,   .0000,   .0000,          00004010
     1                            .0000,   .0010,   .0136,   .0458,          00004020
     2                            .0889,   .1291,   .1550,   .1646,          00004030
     3                            .1615,   .1504,   .1354,   .1192,          00004040
     4                            .1033,   .0889,   .0760,   .0649/          00004050
      DATA(KPS(I,15,4),I=1,20)/   .0000,   .0000,   .0000,   .0000,          00004060
     1                            .0000,   .0000,   .0000,   .0002,          00004070
     2                            .0016,   .0066,   .0155,   .0267,          00004080
     3                            .0378,   .0464,   .0515,   .0535,          00004090
     4                            .0529,   .0505,   .0470,   .0429/          00004100
      DATA(KPS(I,16,4),I=1,20)/   .0000,   .0000,   .0000,   .0000,          00004110
     1                            .0000,   .0000,   .0000,   .0000,          00004120
     2                            .0000,   .0000,   .0000,   .0003,          00004130
     3                            .0009,   .0023,   .0044,   .0069,          00004140
     4                            .0095,   .0119,   .0137,   .0149/          00004150
      DATA(KPS(I,17,4),I=1,20)/   .0000,   .0000,   .0000,   .0000,          00004160
     1                            .0000,   .0000,   .0000,   .0000,          00004170
     2                            .0000,   .0000,   .0000,   .0000,          00004180
     3                            .0000,   .0000,   .0001,   .0002,          00004190
     4                            .0005,   .0009,   .0015,   .0023/          00004200
      DATA(KPS(I,18,4),I=1,20)/   .0000,   .0000,   .0000,   .0000,          00004210
     1                            .0000,   .0000,   .0000,   .0000,          00004220
     2                            .0000,   .0000,   .0000,   .0000,          00004230
     3                            .0000,   .0000,   .0000,   .0000,          00004240
     4                            .0000,   .0000,   .0000,   .0001/          00004250
      DATA(KPS(I,19,4),I=1,20)/   .0000,   .0000,   .0000,   .0000,          00004260
     1                            .0000,   .0000,   .0000,   .0000,          00004270
     2                            .0000,   .0000,   .0000,   .0000,          00004280
     3                            .0000,   .0000,   .0000,   .0000,          00004290
     4                            .0000,   .0000,   .0000,   .0000/          00004300
      DATA(KPS(I, 1,5),I=1,20)/ 77.2823, 53.6270, 39.7366, 28.5512,          00004310
     1                          21.6779, 12.6773,  7.6289,  5.0175,          00004320
     2                           3.4579,  2.4349,  1.7580,  1.3010,          00004330
     3                            .9781,   .7480,   .5816,   .4578,          00004340
     4                            .3647,   .2941,   .2392,   .1965/          00004350
      DATA(KPS(I, 2,5),I=1,20)/ 67.4545, 48.5153, 36.7436, 26.8912,          00004360
     1                          20.6616, 12.2861,  7.4704,  4.9377,          00004370
     2                           3.4142,  2.4101,  1.7433,  1.2920,          00004380
     3                            .9724,   .7443    .5793,   .4561,          00004390
     4                            .3635,   .2932,   .2387,   .1960/          00004400
      DATA(KPS(I, 3,5),I=1,20)/ 55.7589, 42.1670, 32.9282, 24.7281,          00004410
     1                          19.3183, 11.7587,  7.2541,  4.8282,          00004420
     2                           3.3539,  2.3757,  1.7230,  1.2795,          00004430
     3                            .9645,   .7392,   .5759,   .4538,          00004440
     4                            .3619,   .2921,   .2378,   .1954/          00004450
      DATA(KPS(I, 4,5),I=1,20)/ 43.6506, 35.2099, 25.5990, 22.2006,          00004460
     1                          17.7187, 11.1138,  6.9850,  4.6910,          00004470
     2                           3.2779,  2.3323,  1.6971,  1.2635,          00004480
     3                            .9544,   .7326,   .5715,   .4508,          00004490
     4                            .3598,   .2906,   .2368,   .1947/          00004500
      DATA(KPS(I, 5,5),I=1,20)/ 32.3022, 28.2456, 24.0730, 19.4595,          00004510
     1                          15.9424, 1 .3734,  6.6697,  4.5296,          00004520
     2                           3.1874,  2.2603,  1.6661,  1.2443,          00004530
     3                            .9422,   .7246,   .5662,   .4472,          00004540
```

```
4                                .3573,    .2889,    .2355,    .1937/        00004550
 DATA(KPS(I, 6,5),I=1,20)/     22.7226,  21.7692,  19.6384,  16.6531,        00004560
1                              14.0713,   9.5616,   6.3154,   4.3439,        00004570
2                               3.0937,   2.2203,   1.6302,   1.2219,        00004580
3                                .9280,    .7154,    .5599,    .4429,        00004590
4                                .3544,    .2866,    .2340,    .1926/        00004600
 DATA(KPS(I, 7,5),I=1,20)/     15.1096,  16.1197,  15.5267,  13.9140,        00004610
1                              12.1835,   8.7037,   5.9299,   4.1401,        00004620
2                               2.9681,   2.1530,   1.5897,   1.1967,        00004630
3                                .9118,    .7048,    .5528,    .4391,        00004640
4                                .3510,    .2844,    .2323,    .1914/        00004650
 DATA(KPS(I, 8,5),I=1,20)/      9.5152,  11.4661,  11.8973,  11.3502,        00004660
1                              10.3483,   7.3240,   5.5214,   3.9207,        00004670
2                               2.9424,   2.0793,   1.5450,   1.1686,        00004680
3                                .8939,    .6730,    .5449,    .4326,        00004690
4                                .3472,    .2817,    .2303,    .1900/        00004700
 DATA(KPS(I, 9,5),I=1,20)/      5.6749,   7.8360,   8.8351,   9.0395,        00004710
1                               8.6223,   6.9456,   5.0980,   3.6892,        00004720
2                               2.7082,   1.9998,   1.4965,   1.1331,        00004730
3                                .8742,    .6801,    .5362,    .4267,        00004740
4                                .3430,    .2787,    .2282,    .1884/        00004750
 DATA(KPS(I,10,5),I=1,20)/       .4167,   1.1450,   1.9644,   2.8620,        00004760
1                               3.4295,   3.3053,   3.4067,   2.7125,        00004770
2                               2.1211,   1.6425,   1.2739,    .9955,        00004780
3                                .7914,    .6183,    .4942,    .3976,        00004790
4                                .3226,    .2641,    .2177,    .1807/        00004800
 DATA(KPS(I,11,5),I=1,20)/       .0016,    .0192,    .0805,    .2485,        00004810
1                                .4835,   1.0595,   1.4465,   1.4111,        00004820
2                               1.2619,   1.0810,    .9047,    .7491,        00004830
3                                .6155,    .5050,    .4155,    .3424,        00004840
4                                .2833,    .2357,    .1969,    .1653/        00004850
 DATA(KPS(I,12,5),I=1,20)/       .0000,    .0000,    .0000,    .0006,        00004860
1                                .0040,    .0461,    .1772,    .2844,        00004870
2                                .3534,    .3878,    .3910,    .3731,        00004880
3                                .3430,    .3076,    .2717,    .2373,        00004890
4                                .2059,    .1782,    .1539,    .1329/        00004900
 DATA(KPS(I,13,5),I=1,20)/       .0000,    .0000,    .0000,    .0000,        00004910
1                                .0000,    .0006,    .0094,    .0302,        00004920
2                                .0595,    .0923,    .1208,    .1406,        00004930
3                                .1512,    .1536,    .1498,    .1420,        00004940
4                                .1317,    .1205,    .1090,    .0979/        00004950
 DATA(KPS(I,14,5),I=1,20)/       .0000,    .0000,    .0000,    .0000,        00004960
1                                .0000,    .0000,    .0000,    .0000,        00004970
2                                .0004,    .0015,    .0042,    .0087,        00004980
3                                .0146,    .0211,    .0274,    .0327,        00004990
4                                .0368,    .0394,    .0407,    .0409/        00005000
 DATA(KPS(I,15,5),I=1,20)/       .0000,    .0000,    .0000,    .0000,        00005010
1                                .0000,    .0000,    .0000,    .0000,        00005020
2                                .0000,    .0000,    .0000,    .0000,        00005030
3                                .0001,    .0002,    .0006,    .0012,        00005040
4                                .0021,    .0032,    .0044,    .0057/        00005050
 DATA(KPS(I,16,5),I=1,20)/       .0000,    .0000,    .0000,    .0000,        00005060
1                                .0000,    .0000,    .0000,    .0000,        00005070
2                                .0000,    .0000,    .0000,    .0000,        00005080
3                                .0000,    .0000,    .0000,    .0000,        00005090
4                                .0000,    .0000,    .0000,    .0000/        00005100
 DATA(KPS(I,17,5),I=1,20)/       .0000,    .0000,    .0000,    .0000,        00005110
1                                .0000,    .0000,    .0000,    .0000,        00005120
2                                .0000,    .0000,    .0000,    .0000,        00005130
3                                .0000,    .0000,    .0000,    .0000,        00005140
4                                .0000,    .0000,    .0000,    .0000/        00005150
 DATA(KPS(I,18,5),I=1,20)/       .0000,    .0000,    .0000,    .0000,        00005160
1                                .0000,    .0000,    .0000,    .0000,        00005170
2                                .0000,    .0000,    .0000,    .0000,        00005180
```

```
     3                                .0000,    .0000,    .0000,    .0000,          00005190
     4                                .0000,    .0000,    .0000,    .0000/          00005200
      DATA(KPS(I,17,5),I=1,20)/       .0000,    .0000,    .0000,    .0000,          00005210
     1                                .0000,    .0000,    .0000,    .0000,          00005220
     2                                .0000,    .0000,    .0000,    .0000,          00005230
     3                                .0000,    .0000,    .0000,    .0000,          00005240
     4                                .0000,    .0000,    .0000,    .0000/          00005250
      DATA(KPS(I, 1,6),I=1,20)/    103.4149,  75.1796,  57.4313,  42.4226,          00005260
     1                              32.8398,  19.8024,  12.1926,   9.2397,          00005270
     2                               5.8209,   4.1934,   3.0912,   2.3315,          00005280
     3                               1.7641,   1.3871,   1.0955,    .8746,          00005290
     4                                .7063,    .5769,    .4752,    .3947/          00005300
      DATA(KPS(I, 2,6),I=1,20)/     74.0002,  58.5301,  47.1075,  36.3807,          00005310
     1                              28.9940,  18.2240,  11.5195,   7.9750,          00005320
     2                               5.6065,   4.0635,   3.0096,   2.2785,          00005330
     3                               1.7490,   1.3632,   1.0786,    .8628,          00005340
     4                                .6978,    .5707,    .4705,    .3912/          00005350
      DATA(KPS(I, 3,6),I=1,20)/     46.3172,  41.2256,  35.6951,  29.3395,          00005360
     1                              24.3545,  16.2233,  10.6391,   7.3915,          00005370
     2                               5.3196,   3.8524,   2.8993,   2.2065,          00005380
     3                               1.7009,   1.3304,   1.0559,    .8465,          00005390
     4                                .6860,    .5620,    .4641,    .3864/          00005400
      DATA(KPS(I, 4,6),I=1,20)/     25.3578,  26.2707,  24.7864,  22.2508,          00005410
     1                              19.4632,  13.9703,   9.6053,   6.8131,          00005420
     2                               4.9721,   3.6744,   2.7632,   2.1171,          00005430
     3                               1.6411,   1.2894,   1.0271,    .8260,          00005440
     4                                .5712,    .5511,    .4559,    .3803/          00005450
      DATA(KPS(I, 5,6),I=1,20)/     12.1434,  15.1455,  16.1576,  15.8689,          00005460
     1                              14.7983,  11.6371,   8.4773,   6.1674,          00005470
     2                               4.5781,   3.4287,   2.6055,   2.0128,          00005480
     3                               1.5706,   1.2410,    .9931,    .8017,          00005490
     4                                .6535,    .5380,    .4462,    .3729/          00005500
      DATA(KPS(I, 6,6),I=1,20)/      5.0365,   7.8997,   9.6522,  10.6428,          00005510
     1                              10.7047,   9.3767,   7.3136,   5.4826,          00005520
     2                               4.1525,   3.1594,   2.4307,   1.8962,          00005530
     3                               1.4916,   1.1861,    .9542,    .7738,          00005540
     4                                .6332,    .5230,    .4349,    .3643/          00005550
      DATA(KPS(I, 7,6),I=1,20)/      1.8637,   3.7277,   5.3266,   6.7124,          00005560
     1                               7.3671,   7.3085,   6.1680,   4.7865,          00005570
     2                               3.7104,   2.8749,   2.2436,   1.7699,          00005580
     3                               1.4051,   1.1256,    .9113,    .7429,          00005590
     4                                .6106,    .5062,    .4223,    .3547/          00005600
      DATA(KPS(I, 8,6),I=1,20)/       .5973,   1.5915,   2.7155,   3.9811,          00005610
     1                               4.9237,   5.5103,   5.0850,   4.1037,          00005620
     2                               3.2660,   2.5833,   2.0488,   1.6370,          00005630
     3                               1.3132,   1.0611,    .8650,    .7093,          00005640
     4                                .5859,    .4878,    .4084,    .3442/          00005650
      DATA(KPS(I, 9,6),I=1,20)/       .1674,    .6147,   1.2789,   2.2205,          00005660
     1                               3.0049,   4.0188,   4.0980,   3.4553,          00005670
     2                               2.8319,   2.2922,   1.8511,   1.5002,          00005680
     3                               1.2176,    .9932,    .8160,    .6736,          00005690
     4                                .5595,    .4680,    .3934,    .3327/          00005700
      DATA(KPS(I,10,6),I=1,20)/       .0003,    .0050,    .0285,    .1162,          00005710
     1                                .2750,    .8156,   1.3774,   1.4439,          00005720
     2                               1.3778,   1.2530,   1.1085,    .9653,          00005730
     3                                .8309,    .7112,    .6079,    .5188,          00005740
     4                                .4432,    .3796,    .3258,    .2804/          00005750
      DATA(KPS(I,11,6),I=1,20)/       .0000,    .0000,    .0000,    .0002,          00005760
     1                                .0017,    .0275,    .1358,    .2286,          00005770
     2                                .2980,    .3472,    .3728,    .3733,          00005780
     3                                .3689,    .3497,    .3251,    .2978,          00005790
     4                                .2701,    .2434,    .2182,    .1950/          00005800
      DATA(KPS(I,12,6),I=1,20)/       .0000,    .0000,    .0000,    .0000,          00005810
     1                                .0000,    .0000,    .0005,    .0025,          00005820
     2                                  .0070,     .0149,     .0258,     .0381,          00005830
     3                                  .0504,     .0614,     .0701,     .0764,          00005840
     4                                  .0802,     .0819,     .0817,     .0800/          00005850
      DATA(KPS(I,13,6),I=1,20)/         .0000,     .0000,     .0000,     .0000,          00005860
     1                                  .0000,     .0000,     .0000,     .0000,          00005870
     2                                  .0000,     .0002,     .0006,     .0015,          00005880
     3                                  .0031,     .0054,     .0082,     .0114,          00005890
     4                                  .0147,     .0176,     .0206,     .0230/          00005900
      DATA(KPS(I,14,6),I=1,20)/         .0000,     .0000,     .0000,     .0000,          00005910
     1                                  .0000,     .0000,     .0000,     .0000,          00005920
     2                                  .0000,     .0000,     .0000,     .0000,          00005930
     3                                  .0000,     .0000,     .0000,     .0000,          00005940
     4                                  .0001,     .0002,     .0004,     .0007/          00005950
      DATA(KPS(I,15,6),I=1,20)/         .0000,     .0000,     .0000,     .0000,          00005960
     1                                  .0000,     .0000,     .0000,     .0000,          00005970
     2                                  .0000,     .0000,     .0000,     .0000,          00005980
     3                                  .0000,     .0000,     .0000,     .0000,          00005990
     4                                  .0000,     .0000,     .0000,     .0000/          00006000
      DATA(KPS(I,16,6),I=1,20)/         .0000,     .0000,     .0000,     .0000,          00006010
     1                                  .0000,     .0000,     .0000,     .0000,          00006020
     2                                  .0000,     .0000,     .0000,     .0000,          00006030
     3                                  .0000,     .0000,     .0000,     .0000,          00006040
     4                                  .0000,     .0000,     .0000,     .0000/          00006050
      DATA(KPS(I,17,6),I=1,20)/         .0000,     .0000,     .0000,     .0000,          00006060
     1                                  .0000,     .0000,     .0000,     .0000,          00006070
     2                                  .0000,     .0000,     .0000,     .0000,          00006080
     3                                  .0000,     .0000,     .0000,     .0000,          00006090
     4                                  .0000,     .0000,     .0000,     .0000/          00006100
      DATA(KPS(I,18,6),I=1,20)/         .0000,     .0000,     .0000,     .0000,          00006110
     1                                  .0000,     .0000,     .0000,     .0000,          00006120
     2                                  .0000,     .0000,     .0000,     .0000,          00006130
     3                                  .0000,     .0000,     .0000,     .0000,          00006140
     4                                  .0000,     .0000,     .0000,     .0000/          00006150
      DATA(KPS(I,19,6),I=1,20)/         .0000,     .0000,     .0000,     .0000,          00006160
     1                                  .0000,     .0000,     .0000,     .0000,          00006170
     2                                  .0000,     .0000,     .0000,     .0000,          00006180
     3                                  .0000,     .0000,     .0000,     .0000,          00006190
     4                                  .0000,     .0000,     .0000,     .0000/          00006200
      DATA DLIM/1.1,1.4,1.7,2.1,2.5,3.5,4.9,6.4,                                      00006210
     1 8.3,10.6,13.3,16.4,20.0,24.1,28.7,33.9,39.7,46.1,53.2,61./                     00006220
      DATA HLIM/10.,15.,20.,25.,30.,35.,40.,45.,50.,70.,100.,150.,200.,               00006230
     1 300.,450.,700.,1000.,1400.,2000./                                              00006240
      DATA P/0.1,0.15,0.2,0.25,0.25,0.3/                                              00006250
      DATA UC/.666667,.406504,.223714,.144300,.104058,.079872/                        00006260
      DATA IDSK,IRD,IWR,IDSKB,IPU/4,5,6,8,1/                                          00006270
      DATA NA/0/                                                                      00006280
      DATA R/0./,F/0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,                         00006290
     10.,0.,0.,0./                                                                    00006300
      DATA THETA/-0.19891,0.19891,0.66818,1.4966,5.0273,                              00006310
     1-5.0273,-1.4966,-0.66818/                                                       00006320
      DATA AN/0.,0.,0.,0.,0.,0.,0.,0.,0.,0./                                          00006330
      DATA BN/0.,0.,0.,0.,0.,0.,0.,0.,0.,0./                                          00006340
      DATA AAR/.4,.33,.22,.15,.06,.06/                                                00006350
      DATA BAR/.91,.96,.99,.75,.71,.71/                                               00006360
C                                                                                     00006370
C INPUT TITLE AND METEOROLOGY SITE LOCATION                                           00006380
C                                                                                     00006390
      READ(IRD,120)(TT(I),I=1,20)                                                     00006400
  120 FORMAT(20A4)                                                                    00006410
C                                                                                     00006420
C INPUT GRID PARAMETERS                                                               00006430
C XSWC = X-COORDINATE OF SOUTHWEST CORNER OF GRID (WEST EDGE).                        00006440
C YSWC = Y-COORDINATE OF SOUTHWEST CORNER OF GRID (SOUTH EDGE).                       00006450
C LX = NUMBER OF GRID SQUARES PER EAST-WEST ROW (MAXIMUM 50).                         00006460
```

```
C LY = NUMBER OF GRID SQUARES PER NORTH-SOUTH COLUMN (MAXIMUM 50).
C GRID = LENGTH OF SIDE OF GRID SQUARE IN GRID UNITS.
C
      READ(IRD,130)XSWC,YSWC,LX,LY,GRID
  130 FORMAT(2F10.0,2I10,F10.0)
      IF(GRID.GT.1.0E-5) GO TO 136
      WRITE(IWR,135)
  135 FORMAT(1H0,"******ERROR******THE SIZE OF THE RECEPTOR GRID SPACING
     1 CAN NOT BE EQUAL TO ZERO")
      STOP
  136 IF(LX.GE.1.0.AND.LY.GE.1.0) GO TO 139
      WRITE(IWR,137)
  137 FORMAT(1H0,"******ERROR******LX AND LY MUST BE GREATER THAN ZERO")
      STOP
  139 GRIDSQ= GRID*GRID
      VGRID=1./GRID
      XSWR=XSWC-0.5*GRID
      YSWR=YSWC-0.5*GRID
C
C INPUT CONTROL INDICES
C  NRUNS = NUMBER OF SETS OF WEATHER AND EMISSION DATA FOR THIS RUN.
C  NPOL = NUMBER OF POLLUTANTS CONSIDERED (MAXIMUM OF 2)
C       = 1: FIRST POLLUTANT ONLY WILL BE USED
C       = 2: SECOND POLLUTANT ONLY WILL BE USED
C       = 3: BOTH FIRST AND SECOND POLLUTANTS WILL BE USED
C  NPRISE = INDEX FOR DETERMINING WHETHER RISING STAGE OF PLUME RISE
C           WILL BE USED
C          =0: RISING STAGE OF PLUME RISE USED
C          =1: ONLY FINAL PLUME RISE USED
C  NLIST=0: NO LIST PRINTED
C       >0: LIST OF CONCENTRATIONS PRINTED
C  NARRAY=0: NO ARRAY MAP IS PRINTED
C        =1: MAPS OF BOTH UNCALIBRATED AND CALIBRATED CONCENTRATIONS
C                ARE PRINTED
C        =2: MAPS OF UNCALIBRATED CONCENTRATIONS ARE PRINTED
C        =3: MAPS OF CALIBRATED CONCENTRATIONS ARE PRINTED
C  NCSOPT=N: CULPABILITY LIST PRINTED FOR N-TH POLLUTANT;
C        =0: NO CULPABILITY LIST. NCSOPT>0 REQUIRES NPOL=1.
C  NPUNCH=0: RESULTS ARE NOT PUNCHED ONTO CARDS
C        >0: RESULTS ARE PUNCHED ONTO CARDS
C  INTPUN = SPACING OF PUNCHED OUTPUT. THE CONCENTRATION IS PRINTED
C           FOR EVERY INTPUN-TH ROW AND INTPUN-TH COLUMN OF THE
C           PRINTED OUTPUT. THUS EVERY INTRVL*INTPUN-TH ROW, ETC.
C           OF THE GRID.
C  INWX=0: READ METEOROLOGICAL FREQ. FUNCTION FROM DISK(UNIT IDSK)
C     >0: READ FROM CARDS(UNIT IRD)
C  INPTSC=0: READ POINT SOURCE DATA FROM DISK (UNIT IDSK5)
C        >0: READ FROM CARDS (UNIT IRD)
C  IURBAN=0: RURAL DISPERSION WILL BE USED FOR ALL SOURCES
C         1: URBAN DISPERSION WILL BE USED FOR ALL SOURCES
C  NSRCOP=1: GRID AND SOURCE PARAMETERS ARE INPUT IN METRIC UNITS
C         2: GRID AND SOURCE PARAMETERS ARE INPUT IN ENGLISH UNITS
C         3: GRID COORDINATES ARE INPUT IN METRIC UNITS. POINT SOURCE
C            PARAMETERS ARE INPUT IN ENGLISH UNITS
C  NMAX  =0: NO LIST OF MAXIMUM CONCENTRATIONS PRINTED
C        =1: LIST OF MAXIMUM CONCENTRATIONS PRINTED
C
      READ(IRD,140)NRUNS,NPOL,NPRISE,NLIST,NARRAY,
     1     NCSOPT,NPUNCH,INTPUN,INWX,INPTSC,IURBAN,NSRCOP,NMAX
  140 FORMAT(13I2)
      INPOL=NPOL
      IF(NPOL.EQ.3) NPOL=2
      IF(INTPUN.LE.0) INTPUN=1
      IF(NCSOPT.LT.1.OR.(LX.LE.25.AND.LY.LE.25)) GO TO 150
      WRITE(IWR,145)LX,LY
  145 FORMAT(1H1,"*** ERROR - NUMBER OF COLUMNS OR ROWS IN RECEPTOR GRID
     1"/16X,"MAY NOT EXCEED 25 IF CONTROL LIST OPTION IS USED."//16X,
     2"CONTROL LIST WAS REQUESTED WITH ",I2," COLUMNS AND ",I2," ROWS.")
      STOP
  150 IF(NCSOPT.NE.0) NPOL=1
C
C INPUT MEAN AMBIENT TEMPERATURE (CENTIGRADE) FOR EACH RUN.
C
      READ(IRD,160)(TA(IR),IR=1,NRUNS)
  160 FORMAT(8F10.0)
C
C INPUT DECAY HALF-LIFE (HOURS) FOR EACH POLLUTANT.
C
      READ(IRD,160)(HALF(IP),IP=1,NPOL)
      DO 165 I=1,NRUNS
C
C CONVERT TEMPERATURES FROM CENTIGRADE TO KELVIN.
C
      TA(I)=TA(I) + 273.15
C
C INPUT CALIBRATION COEFFICIENTS FOR EACH RUN, EACH POLLUTANT:
C AN = Y-INTERCEPT.
C BN = SLOPE.
C IF AN(1) AND BN(1) ARE ZERO, ALL AN AND BN ARE CALCULATED FROM A
C LEAST-SQUARES FIT OF OBSERVED AND CALCULATED CONCENTRATIONS.
C
  165 READ(IRD,160)AN(I,1),BN(I,1),AN(I,2),BN(I,2)
C
C  INPUT POLLUTANT AND CALIBRATION LABELS
C
      READ(IRD,167)(POLNAM(I,1),I=1,3),(POLNAM(I,2),I=1,3)
  167 FORMAT (2(3A4))
      DO 166 IR=1,NRUNS
  166 READ(IRD,169)(CALNAM(IR,I,1),I=1,7),(CALNAM(IR,I,2),I=1,7)
  169 FORMAT (2(7A4))
C
C INPUT SCALE FACTORS FOR AREA SOURCES.
C
      DO 159 IR=1,NRUNS
  159 READ(IRD,160)(ASCALE(IR,IP),IP=1,NPOL)
      WRITE(IWR,900)
      WRITE(IWR,902)TT
      WRITE(IWR,905)LX,LY,GRID,XSWC,YSWC
      IF(INPOL.EQ.1) WRITE(IWR,906)NRUNS,INTPUN
      IF(INPOL.EQ.2) WRITE(IWR,907)NRUNS,INTPUN
      IF(INPOL.EQ.3) WRITE(IWR,908)NRUNS,INTPUN
      IF(NPRISE.EQ.0) WRITE (IWR,912)
      IF(NPRISE.EQ.1) WRITE (IWR,913)
      IF(IURBAN.EQ.0) WRITE (IWR,909)
      IF(IURBAN.EQ.1) WRITE (IWR,911)
      WRITE(IWR,914)
      IF(NLIST.GT.0) WRITE(IWR,915)
      IF(NARRAY.GT.0) WRITE(IWR,916)
      IF(NPUNCH.GT.0) WRITE(IWR,917)
      IF(NCSOPT.GT.0) WRITE(IWR,918)NCSOPT
      IF(NMAX.GT.0) WRITE(IWR,921)
      DO 170 I=1,NPOL
      IF(HALF(I).GT.9999.) HALF(I)=9999.
      WRITE(IWR,919)I,HALF(I)
  170 HALF(I)=HALF(I)*3600.
      WRITE(IWR,901)
      WRITE(IWR,920)
      DO 175 I=1,NRUNS
  175 WRITE(IWR,922)I,TA(I),(ASCALE(I,J),J=1,2),AN(I,1),BN(I,1),AN(I,2),
     1BN(I,2)
      WRITE(IWR,923)
      WRITE(IWR,901)
      IF(NPUNCH.GT.0) WRITE(IPU,120)TT
C
C READ AND PROCESS METEOROLOGICAL JOINT FREQUENCY FUNCTION
C NOTE: THE JOINT FREQUENCY FUNCTION IS READ FROM DISK
C        CHANGED FROM UNIT IRD TO IDSK ON 26 MAY, 1976 BY MEH
C
      DO 3300 IRUN=1,NRUNS
      CI=(-1)**IRUN
      IF(CI.LT.0) WRITE(IWR,925)IRUN
      IF(CI.GT.0) WRITE(IWR,941)IRUN
      IF(INWX.EQ.0) READ(IDSK,120)(TN(IRUN,IJ),IJ=1,20)
      IF(INWX.NE.0) READ(IRD,120)(TN(IRUN,IJ),IJ=1,20)
      WRITE(IWR,926)(TN(IRUN,IJ),IJ=1,20)
      ZEPHYR=0.
      WTOT=0.
      DO 3170 I=1,6
      WWSUM=0.
      WSUM(I)=0.
      DO 3160 J=1,16
      WR(J,I,IRUN)=0.
      IF(INWX.EQ.0) READ(IDSK,3120)(WIND(K),K=1,6)
      IF(INWX.NE.0) READ(IRD,3120)(WIND(K),K=1,6)
 3120 FORMAT(7X,6F7.5)
      DO 3125 K=1,6
      WWSUM=WWSUM + WIND(K)*UC(K)
 3125 WR(J,I,IRUN)=WR(J,I,IRUN) + WIND(K)
 3160 WSUM(I)=WSUM(I) + WR(J,I,IRUN)
      IF(WWSUM.GT.0.) GO TO 3162
      U(I,IRUN)= 99.
      GO TO 3163
 3162 U(I,IRUN)= WSUM(I)/WWSUM
 3163 DO 3165 K=1,8
      WRTEMP(K)= WR(K,I,IRUN)
      WR(K,I,IRUN)=WR(K+8,I,IRUN)
 3165 WR(K+8,I,IRUN)=WRTEMP(K)
      WTOT=WTOT+WSUM(I)
      IF(U(I,IRUN).LE.0.) GO TO 3170
      ZEPHYR=ZEPHYR + WSUM(I)/U(I,IRUN)
 3170 CONTINUE
      WRITE(IWR,927)
      DO 3200 IW=1,16
      WRITE(IWR,928)IW,(WR(IW,IS,IRUN),IS=1,6)
 3200 CONTINUE
C
C U REPRESENTS THE INVERSE OF THE WEIGHTED MEAN OF THE INVERSE OF
C THE WIND SPEED FOR AN ENTIRE STABILITY CLASS.
C UMEAN IS THE INVERSE OF THE WEIGHTED MEAN OF THE INVERSES OF U.
C
      UMEAN(IRUN)= WTOT/ZEPHYR
      WRITE(IWR,929)(U(IU,IRUN),IU=1,6),UMEAN(IRUN)
 3300 CONTINUE
      DO 5000 IRUN=1,NRUNS
      NA=0
      DO 185 I=1,2
      SUMAB(I)=0
  185 SUMPB(I)=0
C
C INITALIZE THE GRID TO ZERO
C
      DO 186 I=1,LX
      DO 186 J=1,LY
      DO 186 K=1,2
  186 CPS(I,J,K)=0
C
C INPUT AREA SOURCE DATA
C X    = X-COORDINATE, KILOMETERS
C Y    = Y-COORDINATE, KILOMETERS
C SIZE = LENGTH OF SIDE OF AREA SOURCE, METERS
C E(N) = EMISSION RATE OF POLLUTANT NO, GRAMS/SECOND
C SID  = SOURCE IDENTIFICATION
C
      IF(INPOL.EQ.2) NPOL=1
  215 READ(IRD,225)X,Y,SIZE,E(1),E(2),SID
  225 FORMAT(F6.2,F7.2,F7.0,2F9.0,32X,2A4)
      IF(SIZE.LT.1.0E-5) GO TO 4225
      NA=NA+1
      SUMAQ(1)=SUMAQ(1)+E(1)
      SUMAQ(2)=SUMAQ(2)+E(2)
      IF(NCSOPT.EQ.2) E(1)=E(2)
      IF(INPOL.EQ.2) E(1)=E(2)
      IF((NA-1)/50*50.NE.(NA-1)) GO TO 226
      WRITE(IWR,900)
      WRITE(IWR,930)TT
      WRITE(IWR,931)
  226 WRITE(IWR,932)NA,X,Y,SIZE,E(1),E(2),SID
      SIZE=SIZE*0.001
      AREA= SIZE*SIZE
C
C INITIALIZE THE AREA SOURCE GRID TO ZERO
C
      DO 185 I=1,LX
      DO 185 J=1,LY
      DO 185 K=1,2
  185 G(I,J,K)=0
      AX1= X
      AX2= AX1 + SIZE
      MX1= (AX1-XSWR)*VGRID + 1.
      MX2= (AX2-XSWR)*VGRID + 1.
      NX1= MX1 + 4.
      NX2= MX2 + 4.
      IF(NX1.GT.LX+8.OR.NX2.LT.1) GO TO 215
      IF(NX1.GE.1) GO TO 32
      NX1= 1
      AX1= XSWR - 4.*GRID
   32 IF(NX2.LE.LX+8) GO TO 34
      NX2= LX+8
      AX2= XSWR + (LX + 4.)*GRID
   34 X1= XSWR + (FLOAT(NX1)-5.)*GRID
      X2= XSWR + (FLOAT(NX2)-4.)*GRID
      AY1= Y
      AY2= AY1 + SIZE
      MY1= (AY1-YSWR)*VGRID + 1.
      MY2= (AY2-YSWR)*VGRID + 1.
      NY1= MY1 + 4.
      NY2= MY2 + 4.
      IF(NY1.GT.LY+8.OR.NY2.LT.1) GO TO 215
      IF(NY1.GE.1) GO TO 36
      NY1= 1
      AY1= YSWR - 4.*GRID
   36 IF(NY2.LE.LY+8) GO TO 38
      NY2= LY+8
      AY2= YSWR + (LY + 4.)*GRID
   38 Y1= YSWR + (FLOAT(NY1)-5.)*GRID
      Y2= YSWR + (FLOAT(NY2)-4.)*GRID
      DO 1025 I=MX1,MX2
      IF(MX1.NE.MX2) GO TO 10
      DX= AX2-AX1
      GO TO 13
   10 IF(I.NE.MX1) GO TO 11
      DX= GRID+X1-AX1
      GO TO 13
   11 IF(I.NE.MX2) GO TO 12
      DX= GRID+AX2-X2
      GO TO 13
   12 DX=GRID
   13 DO 1024 J=MY1,MY2
      IF(MY1.NE.MY2) GO TO 20
      DY= AY2-AY1
      GO TO 23
   20 IF(J.NE.MY1) GO TO 21
      DY= GRID+Y1-AY1
      GO TO 23
   21 IF(J.NE.MY2) GO TO 22
      DY= GRID+AY2-Y2
      GO TO 23
   22 DY= GRID
   23 SPLIT= DX*DY/(AREA*GRIDSQ)
      DO 1023 IP=1,NPOL
      DO 1022 IS=1,6
      IF (IURBAN.EQ.1) GO TO 974
      IA=IS
      GO TO 975
  974 IA=IS-1
      IF (IA.EQ.0) IA=1
  975 AA=AAR(IA)
      BA=1.-BAR(IA)
      QC=0.79788456*(0.5*GRID)**BA/(U(IA,IRUN)*AA*BA)
      Q03=3.**BA
      Q5=5.**BA
      Q7=7.**BA
      Q9=9.**BA
      QN(1)=Q03-1
      QN(2)=Q5-Q03
      QN(3)=Q7-Q5
      QN(4)=Q9-Q7
      DO 1021 K=1,16
      IF(I.GT.0.AND.J.GT.0) G(I,J,IP)=G(I,J,IP)+QC*E(IP)*SPLIT*WR(K,IS,
     1IRUN)
      IF(K.EQ.1.OR.K.EQ.9) GO TO 1000
      IF(K.EQ.5.OR.K.EQ.13) GO TO 1001
      IF(K.EQ.11.OR.K.EQ.15) GO TO 1002
      IF(K.EQ.3.OR.K.EQ.7) GO TO 1003
      IF(K.EQ.4.OR.K.EQ.6) GO TO 1004
      IF(K.EQ.12.OR.K.EQ.14) GO TO 1005
      IF(K.EQ.2.OR.K.EQ.15) GO TO  1006
      GO TO 1007
 1000 DO 1031 L=1,4
      IL=0
      JL=L*(-1)**((K+15)/8)
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1031
      IF(N.LT.1) GO TO 1031
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1031 CONTINUE
      GO TO 1021
 1001 DO 1032 L=1,4
```

```
      JL=0
      IL=L*(-1)**((K+11)/8)
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1032
      IF(N.LT.1) GO TO 1032
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1032 CONTINUE
      GO TO 1021
 1002 DO 1033 L=1,3
      IL=(-1)*L
      JL=L*(-1)**((K+1)/4)
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1033
      IF(N.LT.1) GO TO 1033
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1033 CONTINUE
      GO TO 1008
 1003 DO 1034 L=1,3
      IL=L
      JL=L*(-1)**((K+5)/4)
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1034
      IF(N.LT.1) GO TO 1034
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1034 CONTINUE
      GO TO 1009
 1004 DO 1035 L=1,4
      IL=L
      JL=INT(L/2)*(-1)**(K/2)
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1040
      IF(N.LT.1) GO TO 1040
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1040 IF(K.EQ.6.AND.L.EQ.4) GO TO 1012
      IF(K.EQ.4.AND.L.EQ.4) GO TO 1010
      GO TO 1035
 1012 NN=N+1
      IF(NN.GT.1.AND.M.GT.0) G(M,NN,IP)=G(M,NN,IP)+GL(M,N,IP)
      IF(NN.EQ.1.AND.M.GT.0) G(M,NN,IP)=G(M,NN,IP)+GL(M,N+2,IP)
      GO TO 1035
 1013 NN=N-1
      IF(NN.GT.0.AND.M.GT.0) G(M,NN,IP)=G(M,NN,IP)+GL(M,N,IP)
 1035 CONTINUE
      GO TO 1021
 1005 DO 1036 L=1,6
      IL=(-1)*L
      JL=INT(L/2)*(-1)**((K/2)+1)
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1041
      IF(N.LT.1) GO TO 1041
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1041 IF(K.EQ.12.AND.L.EQ.6) GO TO 1015
      IF(K.EQ.14.AND.L.EQ.6) GO TO 1011
      GO TO 1036
 1015 NN=N+1
      IF(NN.GT.1.AND.M.GT.0) G(M,NN,IP)=G(M,NN,IP)+GL(M,N,IP)
      GO TO 1036
 1011 NN=N-1
      IF(NN.GT.0.AND.M.GT.0) G(M,NN,IP)=G(M,NN,IP)+GL(M,N,IP)
 1036 CONTINUE
      GO TO 1021
 1006 DO 1037 L=1,4
      IL=INT(L/2)*(-1)**((K/2)+1)
      JL=L
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1042
      IF(N.LT.1) GO TO 1042
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1042 IF(L.NE.4) GO TO 1037
      IF(K.EQ.16) GO TO 1019
      IF(K.EQ.2) GO TO 1013
 1019 MM=M+1
      IF(MM.GT.1.AND.N.GT.0) G(MM,N,IP)=G(MM,N,IP)+GL(M,N,IP)
      IF(MM.EQ.1.AND.N.GT.0) G(MM,N,IP)=G(MM,N,IP)+GL(M+2,N,IP)
      GO TO 1037
 1013 MM=M-1
      IF(MM.GT.0.AND.N.GT.0) G(MM,N,IP)=G(MM,N,IP)+GL(M,N,IP)
 1037 CONTINUE
      GO TO 1021
 1007 DO 1038 L=1,4
      IL=INT(L/2)*(-1)**(K/2)
      JL=(-1)*L
      M=I+IL
      N=J+JL
      IF(M.LT.1) GO TO 1039
      IF(N.LT.1) GO TO 1039
      GL(M,N,IP)=QC*QN(L)*E(IP)*SPLIT*WR(K,IS,IRUN)
      G(M,N,IP)=G(M,N,IP)+GL(M,N,IP)
 1039 IF(K.EQ.10.AND.L.EQ.4) GO TO 1018
      IF(K.EQ.8.AND.L.EQ.4) GO TO 1014
      GO TO 1038
 1018 MM=M+1
      IF(MM.GT.1.AND.N.GT.0) G(MM,N,IP)=G(MM,N,IP)+GL(M,N,IP)
      IF(MM.EQ.1.AND.N.GT.0) G(MM,N,IP)=G(MM,N,IP)+GL(M+2,N,IP)
      GO TO 1038
 1014 MM=M-1
      IF(MM.GT.0.AND.N.GT.0) G(MM,N,IP)=G(MM,N,IP)+GL(M,N,IP)
      II=I+2
      JJ=J-3
      IF(II.GT.1.AND.JJ.GT.0) G(I+2,JJ,IP)=G(I+2,JJ,IP)+(GL(I+1,JJ,IP)+
     1GL(I+3,JJ,IP))*.5
      IF(II.EQ.1.AND.JJ.GT.0) G(I+2,JJ,IP)=G(I+2,JJ,IP)+GL(I+3,JJ,IP)
 1038 CONTINUE
      GO TO 1021
 1009 IR=(-1)**((K+5)/4)
      JM=J+2*IR
      JN=J+3*IR
      II=I+2
      IF(K.EQ.7) GO TO 1016
      IF(II.GT.1.AND.JN.GT.0) G(I+2,JN,IP)=G(I+2,JN,IP)+(GL(I+1,JN,IP)+
     1GL(I+3,JN,IP))*.5
      IF(II.EQ.1.AND.JN.GT.0) G(I+2,JN,IP)=G(I+2,JN,IP)+GL(I+3,JN,IP)
      IF(K.EQ.3) GO TO 1021
 1016 JJ=J+1
      IF(II.GE.0.AND.JJ.GT.0) G(I+3,J+2,IP)=G(I+3,J+2,IP)+(GL(I+3,J+3,
     1IP)+GL(I+3,JJ,IP))*.5
```

```
      IF(II.GE.0.AND.JJ.EQ.0) G(I+3,J+2,IP)=G(I+3,J+2,IP)+GL(I+3,J+3,IP)
      IF(II.GE.0.AND.JN.EQ.0) G(I+3,JM,IP)=G(I+3,JM,IP)+GL(I+3,J-1,IP)
      IF(II.GE.0.AND.JN.GT.0) G(I+3,JM,IP)=G(I+3,JM,IP)+(GL(I+3,J-1,IP)+
     1GL(I+3,JN,IP))*.5
      GO TO 1021
 1006 IR=(-1)**((K+1)/4)
      JM=J+2*IR
      JN=J+3*IR
      II=I-3
      IF(K.EQ.15) GO TO 1017
      IF(II.GT.0.AND.JN.GT.0) G(I-2,JN,IP)=G(I-2,JN,IP)+(GL(I-1,JN,IP)+
     1GL(I-3,JN,IP))*.5
      IF(II.EQ.0.AND.JN.GT.0) G(I-2,JN,IP)=G(I-2,JN,IP)+GL(I-1,JN,IP)
      IF(K.EQ.11) GO TO 1021
 1017 JJ=J-2
      IF(II.GT.0.AND.JJ.GT.1) G(I-3,J-2,IP)=G(I-3,J-2,IP)+(GL(I-3,J-3,
     1IP)+GL(I-3,J-1,IP))*.5
      IF(II.GT.0.AND.JJ.EQ.1) G(I-3,JJ,IP)=G(I-3,JJ,IP)+GL(I-3,J-1,IP)
      IF(II.GT.0.AND.JM.GT.1) G(I-3,JM,IP)=G(I-3,JM,IP)+(GL(I-3,J+1,IP)
     1+GL(I-3,J+3,IP))*.5
      IF(II.GT.0.AND.JM.EQ.1) G(I-3,JM,IP)=G(I-3,JM,IP)+GL(I-3,J+3,IP)
      GO TO 1021
 1021 CONTINUE
      II=I-4
      NN=J-1
      IF(NN.EQ.1.AND.II.GE.1) G(II,NN,IP)=G(II,NN,IP)+GL(II,J,IP)
      II=I-2
      NN=J+3
      IF(II.GT.1.AND.NN.GT.0) G(I-2,J+3,IP)=G(I-2,J+3,IP)+(GL(I-1,J+3,
     1IP)+GL(I-3,J+3,IP))*.5
      IF(II.EQ.1.AND.NN.GT.0) G(I-2,J+3,IP)=G(I-2,J+3,IP)+GL(I-1,J+3,IP)
 1022 CONTINUE
 1023 CONTINUE
 1024 CONTINUE
 1025 CONTINUE
      DO 325 K=1,NPOL
      DO 325 I=1,LX
      DO 325 J=1,LY
  325 CPS(I,J,K)=CPS(I,J,K)+G(I,J,K)*ASCALE(IRUN,K)
      GO TO 215
 4225 IF(NA.GE.1) WRITE(IWR,933)SUMAQ(1),SUMAQ(2)
      IF(NCSOPT.LT.1) GO TO 4227
      DO 4226 K=1,5
      DO 4226 I=1,LX
      DO 4226 J=1,LY
      NWCRST(I,J,K)= 0
 4226 CWCRST(I,J,K)= 0.
 4227 IPT=0
C
C INPUT POINT SOURCE DATA
C X     = X-COORDINATE, KILOMETERS
C Y     = Y-COORDINATE, KILOMETERS
C E(N) = EMISSION RATE OF POLLUTANT N, GRAMS/SECOND.
C H     = SOURCE HEIGHT, METERS
C D     = SOURCE DIAMETER, METERS
C V     = EXIT VELOCITY, METERS/SECOND
C T     = EXIT TEMPERATURE, DEGREES CENTIGRADE
C SID  = SOURCE IDENTIFICATION
C
      IF(INPOL.EQ.2) NPOL=1
 4242 IF(INPTSC.EQ.0) READ(IDSK9,227)X,Y,E(1),E(2),H,D,V,T,SID(1),SID(2)
      IF(NSRCOP.EQ.2) GO TO 231
      IF(NSRCOP.EQ.3) GO TO 233
      IF(INPTSC.NE.0) READ(IRD,227)X,Y,E(1),E(2),H,D,V,T,SID(1),SID(2)
  227 FORMAT(F6.2,F7.2,7X,2F9.0,F7.0,F5.0,2F7.0,8X,2A4)
      IF(X + Y + E(1)+E(2).LT.1.0E-5) GO TO 355
      T=T+273.15
      GO TO 238
  231 READ(IRD,232)SID(1),X,Y,E(1),H,D,V,ACFM,T
  232 FORMAT(A4,1X,7F10.0,F5.0)
      X=X*.0003048
      Y=Y*.0003048
      GO TO 235
  233 READ(IRD,234) X,Y,E(1),E(2),H,D,V,T,ACFM,SID
  234 FORMAT(2F9.0,3F7.0,F6.0,3F7.0,9X,2A4)
  235 IF(X + Y + E(1)+E(2).LT.1.0E-5) GO TO 355
      IF(V.GT.1.0E-5.OR.ACFM.LT.1.0E-5)GO TO 236
      IF(D.LE.0) STOP
      V=ACFM/(47.1239*D*D)
  236 E(1)=E(1)*.125997
      E(2)=E(2)*.125997
      H=H*.3048
      D=D*.3048
      V=V*.3048
      T=273.15 + (T - 32.)*.555556
  238 IPT= IPT+1
      SUMPQ(1)=SUMPQ(1)+E(1)
      SUMPQ(2)=SUMPQ(2)+E(2)
      IF((IPT-1)/50*50.NE.IPT-1) GO TO 239
      WRITE(IWR,900)
      WRITE(IWR,935)TT,IRUN
      WRITE(IWR,940)
  239 WRITE(IWR,945)IPT,X,Y,H,D,V,T,E(1),E(2),SID
      IF(INPOL.EQ.2) E(1)=E(2)
      IF(INPOL.EQ.2) HALF(1)=HALF(2)
      IF(NCSOPT.EQ.0) GO TO 228
      IF(NCSOPT.EQ.2) E(1)= E(2)
      E(2)=0.
  228 IF(H.LE.10) VUM=1/UMEAN(IRUN)
      IF(H.GT.10) VUM=((10./H)**0.25)/UMEAN(IRUN)
C
C CALCULATE DECAY FACTORS FOR EACH POLLUTANT FOR 18 DOWNWIND DISTANCES
C TO 61.0 KM., USING MEAN INVERSE WIND SPEED AT PHYSICAL STACK HEIGHT
C
      DO 269 ID=1,20
      DIST=DLIM(ID)*1000.
      DO 268 IP=1,NPOL
  268 DECAY(ID,IP)=EXP(-0.692*DIST*VUM/HALF(IP))
      EFF=2.45*V*D*D*(T-TA(IRUN))/T
      IF(EFF.LT.0) EFF=1.0E-7
      DO 259 IS=1,6
      VUE(IS)=1./U(IS,IRUN)
      IF(H.GT.10.) VUE(IS)=VUE(IS)*((10./H)**P(IS))
      IF(H.GT.10.AND.IURBAN.EQ.1) VUE(6)=VUE(6)*((10./H)**P(5))/((
     110./H)**P(6))
      IRISE=2
      IBUOY(IS)=1
      IF(IS.LT.6.OR.IURBAN.EQ.1) GO TO 240
      IF(V.GT.115.28*(T-TA(IRUN))*SQRT(TA(IRUN))/T) IBUOY(IS)=0
      GO TO 242
  240 AFF=21.425
      BFF=0.75
      IF(EFF.LT.55) GO TO 241
      AFF=38.710
      BFF=0.6
  241 IF(3.*V*D.GT.AFF*EFF**BFF) IBUOY(IS)=0
C
C CALL SUBROUTINE RISE WITH IRISE=2  TO GET PEAK EFFECTIVE SOURCE
```

```
      CALL RISE(IRISE,VUE,IBUOY,EFF,XS,ESH,ESHH,V,D,DIST,H,TA,IRUN,IS,
     1IURBAN)
      HH(IS)=ESHH(IS)
C
C FOR EACH STABILITY CLASS, DETERMINE FACTORS NSH,FSH FOR
C INTERPOLATION TO CORRECT EFFECTIVE STACK HEIGHT IN KPS TABLE.
C
      IF(HH(IS).GT.10.) GO TO 269
      NSH(IS)=1
      FSH(IS)=0.
      GO TO 295
  269 IF(HH(IS).LT.2000.) GO TO 270
      NSH(IS)=18
      FSH(IS)=0
      GO TO 295
  270 DO 272 JS=2,19
      IF(HH(IS).LE.HLIM(JS)) GO TO 275
  272 CONTINUE
  275 NSH(IS)=JS-1
      FSH(IS)= (HH(IS)-HLIM(JS-1))/(HLIM(JS)-HLIM(JS-1))
      GO TO 295
  279 FSH(IS)=FSHH(IS)
      NSH(IS)=NSHH(IS)
      HH(IS)=ESH(IS)
  295 CONTINUE
C
C INTERPOLATE IN KPS TABLE FOR THE VALUE CORRESPONDING TO THE
C POINT SOURCE - GRID SQUARE DISTANCE AND THE EFFECTIVE
C STACK HEIGHT OF THE POINT SOURCE.
C
      CALL KCALC(DSQ,NSH,FSH,NDIST,KAY,HH,DLIM,IURBAN)
C
C CALCULATE CONCENTRATION DUE TO POINT SOURCE AT CENTER OF GRID
C SQUARE, ADD TO TOTAL POINT SOURCE CONCENTRATION THERE.
C
      DO 296 IP=1,NPOL
      CHI= 0.
      DO 295 IS=1,6
  295 CHI= CHI + KAY(IS)*FREQ(IS)*VUE(IS)*DECAY(NDIST,IP)*E(IP)
      IF(NCSOPT.EQ.0) GO TO 296
      CALL WORST(I,J,CHI)
  296 CPS(I,J,IP)= CPS(I,J,IP) + CHI
  300 CONTINUE
C
C READ DATA FOR NEXT POINT SOURCE.
C
      GO TO 4242
C
C IF CALIBRATION COEFFICIENTS FOR THE FIRST POLLUTANT ARE NOT ZERO,
C LEAST-SQUARES CALIBRATION IS SKIPPED
C
  355 WRITE(IWR,946)SUMPG(1),SUMPQ(2)
      IF(NA.EQ.0) WRITE(IWR,933)SUMAQ(1),SUMAQ(2)
      IF(AN(IRUN,1)+BN(IRUN,1).GT.1.0E-7) GO TO 1850
      R=0.
      XKX=XSWR + GRID/2.
      YKY=YSWR + GRID/2.
C
C BEGIN LEAST-SQUARES REGRESSION ANALYSIS AND CALIBRATION.
C
  550 R= R+1.
      NR= R + 0.1
C
C READ RECEPTOR DATA.
```

```
C HEIGHT, ESH(IS)
C
  262 CALL RISE(IRISE,VUE,IBUOY,EFF,XS,ESH,ESHH,V,D,DIST,H,TA,IRUN,IS,
     1IURBAN)
      IF(IBUOY(IS).EQ.0) GO TO 251
      IF(IS.LT.6.OR.IURBAN.EQ.1) GO TO 250
      PEAK(IS)=0.00207148/(VUE(IS)*SQRT(.1961/TA(IRUN)))
      GO TO 252
  250 PEAK(IS)=0.001*XS
      GO TO 252
  251 PEAK(IS)=0
      IF(IS.EQ.6.AND.IURBAN.EQ.0) GO TO 252
      IF(ABS(V).LT..000001) GO TO 252
      PEAK(IS)=.0039992*D*((V+3./VUE(IS))**2)*VUE(IS)/V
C
C FOR EACH STABILITY CLASS, DETERMINE FACTORS NSH, FSH FOR
C INTERPOLATION TO CORRCT EFFECTIVE STACK HEIGHT IN KPS TABLE
C
  252 HH(IS)=ESH(IS)
      IF(HH(IS).GT.10.) GO TO 253
      NSHH(IS)=1
      GO TO 259
  253 IF(HH(IS).LT.2000.) GO TO 254
      NSHH(IS)=18
      FSHH(IS)=0
      GO TO 259
  254 DO 255 J=2,19
      IF(HH(IS).LE.HLIM(J)) GO TO 256
  255 CONTINUE
  256 NSHH(IS)=J-1
      FSHH(IS)=(HH(IS)-HLIM(J-1))/(HLIM(J)-HLIM(J-1))
  259 CONTINUE
C
C CALCULATE CONCENTRATIONS FROM POINT SOURCE AT THE CENTER
C OF EACH GRID SQUARE.
C
      DO 300 I=1,LX
      XI=I
      XCGS= XSWR + (XI-0.5)*GRID
      XD= XCGS - X
      XDSQ= XD*XD
      DO 300 J=1,LY
      YJ=J
      YCGS= YSWR + (YJ - 0.50001)*GRID
      YD= YCGS - Y
      DSQ= XDSQ + YD*YD
C
C IF POINT SOURCE IS OVER 61.0 KM. FROM CENTER OF GRID SQUARE,
C SKIP TO NEXT GRID SQUARE.
C
      IF(DSQ.GT.3721.OR.DSQ.LT.0.0098) GO TO 300
C
C FIND ENTRY IN JOINT FREQUENCY FUNCTION FOR THE APPROPRIATE
C POINT SOURCE - GRID SQUARE WIND DIRECTION, ALL STABILITY CLASSES.
C
      CALL SECTOR(XD,YD,IRUN,FREQ)
      IRISE=1
      DIST=SQRT(DSQ)
      DO 285 IS=1,6
C
C CHECK TO SEE IF ONLY FINAL PLUME RISE IS TO BE USED
C
      IF (NPRISE.EQ.1) GO TO 279
      IF(DIST.GE.PEAK(IS)) GO TO 279
```

```
C XR,YR = POSITION
C CR = CONCENTRATION
C
      READ(IND,555)XR(NR),YR(NR),CR(NR,1),CR(NR,2)
  555 FORMAT(F6.2,F7.2,7X,2F5.0)
      IF(XR(NR)+YR(NR)+CR(NR,1)+CR(NR,2).LT.1.0E-5) GO TO 575
      IF(NCSOPT.EQ.0) GO TO 556
      IF(NCSOPT.EQ.2) CR(NR,1)=CR(NR,2)
      CR(NR,2)=0.
  556 KX=(XR(NR)-XSWR)*VGRID + 1.
      RX=KX
      XK=(RX-0.5)*GRID + XSWR
      DXKX=ABS(XR(NR) - XKX)
      IF(DXKX.LT.0.00001) GO TO 558
      IF(XR(NR).GT.XK) GO TO 558
      KX=KX-1
      RX=KX
      XK=(RX-0.5)*GRID + XSWR
  558 IF(KX.LT.1.OR.KX+1.GT.LX) GO TO 2571
      DX=(XR(NR)-XK)*VGRID
      DXM= 1.-DX
      KY=(YR(NR)-YSWR)*VGRID + 1.
      RY=KY
      YK=(RY-0.5)*GRID + YSWR
      DYKY=ABS(YR(NR) -YKY)
      IF(DYKY.LT.0.00001) GO TO 560
      IF(YR(NR).GT.YK) GO TO 560
      KY=KY-1
      RY=KY
      YK=(RY-0.5)*GRID + YSWR
  560 IF(KY.LT.1.OR.KY+1.GT.LY) GO TO 2571
      DY=(YR(NR)-YK)*VGRID
      DYM= 1.-DY
      DO 565 IP=1,NPOL
      C1(IP)= CPS(KX,KY,IP)
      C2(IP)= CPS(KX+1,KY,IP)
      C3(IP)= CPS(KX,KY+1,IP)
      C4(IP)= CPS(KX+1,KY+1,IP)
      Q1(IP)= G(KX,KY,IP)
      Q2(IP)= G(KX+1,KY,IP)
      Q3(IP)= G(KX,KY+1,IP)
      Q4(IP)= G(KX+1,KY+1,IP)
      CA(IP)=  C1(IP)*DXM + C2(IP)*DX
      CB(IP)=  C3(IP)*DXM + C4(IP)*DX
      QA(IP)=  Q1(IP)*DXM + Q2(IP)*DX
      QB(IP)=  Q3(IP)*DXM + Q4(IP)*DX
      CSUM(NR,IP)= CA(IP)*DYM + CB(IP)*DY
  565 QSUM(NR,IP)= QA(IP)*DYM + QB(IP)*DY
      GO TO 550
 2571 WRITE(IWR,956)XR(NR),YR(NR)
      R= R - 1.
      GO TO 550
  575 CONTINUE
      IF(NR.GT.2) GO TO 577
      WRITE(IWR,576)
  576 FORMAT(1H1,"******ERROR******THE NUMBER OF MONITORING SITES FOR A
     1LEAST SQUARES FIT MUST BE GREATER THAN 1")
      STOP
  577 CSUMMX=0.
      DO 1700 IR=1,NR
      IF(IR.EQ.NR) GO TO 1610
      DO 1600 IP=1,NPOL
      CRR(IP)=CR(IR,IP)
 1600 CF(IP)=CSUM(IR,IP)+QSUM(IR,IP)
```

```
      GO TO 1695
 1610 DO 1620 IP=1,NPOL
 1620 CRR(IP)=0.
 1695 IF((IR-1)/40*40.NE.(IR-1)) GO TO 1697
      WRITE(IWR,900)
      WRITE(IWR,950)TT,IRUN
      WRITE(IWR,955)
 1697 IF(CRR(1)+CRR(2).GT.1.0E-5) WRITE(IWR,960) IR,
     1XR(IR),YR(IR),(CRR(IP),IP=1,2),(CF(IP),IP=1,2)
C
C SUBROUTINE REGAN PERFORMS REGRESSION ANALYSIS; RETURNS CALIBRATION
C COEFFICIENTS, CORRELATION COEFFICIENT, AND STANDARD ERROR.
C
 1700 CALL REGAN(IRUN,NPOL,IR,NR,CF,CRR,AN,BN,CORREL,STDERR)
      CSUMF=0.
C
C CALIBRATE AND OUTPUT PREDICTED CONCENTRATIONS
C
 1850 DO 700 I=1,LX
      IF(NLIST.LT.1) GO TO 605
      WRITE(IWR,900)
      WRITE(IWR,963)IRUN,TT
      WRITE(IWR,962)
      WRITE(IWR,965)
  605 XI=I
      X= XSWR +(XI-0.5)*GRID
      DO 700 J=1,LY
      YJ=J
      Y= YSWR +(YJ-0.5)*GRID
      DO 620 K=1,2
  620 CCALIB(K)=AN(IRUN,K) + BN(IRUN,K)*CPS(I,J,K)
      IF(NLIST.GT.0) WRITE(IWR,970)I,J,X,Y,(CPS(I,J,K),K=1,2),
     1(CCALIB(K),K=1,2)
      IF(NPUNCH.LT.1) GO TO 700
      IF(((I-1)/INTPUN)*INTPUN.NE.(I-1).OR.((J-1)/INTPUN)*INTPUN.NE.
     1(J-1)) GO TO 700
      WRITE(IPU,636)X,Y,(CPS(I,J,IP),IP=1,2),(CCALIB(IP),IP=1,2)
  636 FORMAT(6F10.4)
  700 CONTINUE
      IF(NARRAY.GE.1) CALL ARRAY(IRUN,NPOL,INPOL,AN,BN,TT,TN,IURBAN,
     1NARRAY,POLNAM,CALNAM)
      IF(NCSCPT.GE.1) CALL WORCUT(TT,IRUN,TN)
      IF(NMAX.GT.0) CALL MAXOUT(IRUN,NRUNS,NPOL,INPOL,AN,BN,IURBAN,
     1TT,TN,CALNAM,POLNAM)
 5000 CONTINUE
  900 FORMAT(1H1,29X,"T E X A S   C L I M A T O L O G I C A L   M O D E
     1L  -  V E R S I O N - 2",/)
  901 FORMAT(1H0,128("-"))
  902 FORMAT(1H0,25X,20A4)
  905 FORMAT(1H0,"RECEPTOR GRID CONSISTS OF ",I2," COLUMNS AND ",I2," RO
     1WS, SPACED",F7.3,"KM. APART.  SOUTHWEST CORNER OF GRID =",F7.2,"KM
     2,   ",F7.2,"KM.")
  906 FORMAT(1H0,34X,I1," RUN(S) WITH THE FIRST POLLUTANT AND INTPUN = "
     1,I2)
  907 FORMAT(1H0,33X,I1," RUN(S) WITH THE SECOND POLLUTANT AND INTPUN =
     1",I2)
  908 FORMAT(1H0,29X,I1," RUN(S) WITH BOTH THE FIRST AND SECOND POLLUTAN
     1TS AND INTPUN = " ,I2)
  909 FORMAT(41X,"RURAL DISPERSION WILL BE USED FOR POINT SOURCES")
  911 FORMAT(41X,"URBAN DISPERSION WILL BE USED FOR POINT SOURCES")
  912 FORMAT(45X,"RISING STAGE OF PLUME RISE WILL BE USED")
  913 FORMAT(43X,"ONLY FINAL STAGE OF PLUME RISE WILL BE USED")
  914 FORMAT(1H0,43X,"TYPES OF OUTPUT TO BE PRODUCED BY THIS RUN:")
  915 FORMAT(50X,"LIST")
  916 FORMAT(60X,"ARRAY MAP")                                           00014770
  917 FORMAT(60X,"PUNCHED CARDS")                                       00014780
  918 FORMAT(60X,"CULPABILITY LIST FOR POLLUTANT ",I1)                  00014790
  919 FORMAT(1H0,40X,"DECAY HALF-LIFE OF POLLUTANT ",I1," = ",F8.5," HOU 00014800
     1RS.")                                                             00014810
  920 FORMAT(1H0,31X,"AREA SOURCE EMISSION SCALING FACTORS",16X,"CONCENT 00014820
     1RATION CALIBRATION FACTORS"/1H ,"RUN NO.  MEAN TEMPERATURE"/1H ,  00014830
     2 41X,"P 1",9X,"P 2",26X,"A 1         B 1         A 2        B 2") 00014840
  922 FORMAT(4X,I1,10X,F6.2," K",16X,2(F9.4,4X),15X,4(2X,F9.4))          00014850
  923 FORMAT(1H0,91X,"CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC")   00014855
  921 FORMAT(50X,"LIST OF MAXIMUM CONCENTRATIONS")                      00014860
  925 FORMAT(1H0,38X,"METEOROLOGICAL JOINT FREQUENCY FUNCTION FOR RUN ", 00014870
     1 I1/)                                                             00014880
  941 FORMAT(1H1,38X,"METEOROLOGICAL JOINT FREQUENCY FUNCTION FOR RUN ", 00014890
     1 I1/)                                                             00014900
  926 FORMAT(1H0,36X,20A4)                                              00014910
  927 FORMAT(1H0,"WIND SECTOR    STABILITY CLASS:",6X,"A",11X,"B",11X,  00014920
     1"C",11X,"DD",10X,"DN",9X,"E+F")                                   00014930
  928 FORMAT(6X,I2,21X,5F12.6)                                          00014940
  929 FORMAT(1H0,"MEAN WIND SPEEDS, METERS/SECOND  ",6(F7.4,5X),        00014950
     1"OVERALL MEAN = ",F7.4,///)                                       00014960
  930 FORMAT(1H0,"AREA SOURCE LIST:  ",20A4)                            00014970
  933 FORMAT(1H0,"THE SUM OF THE AREA SOURCE EMISSION RATES FOR THIS RUN 00014980
     1 IS   ",F9.2,"G/S FOR POLLUTANT 1,  ",F9.2,"G/S FOR POLLUTANT 2") 00014990
  931 FORMAT(1H0,"SOURCE NUMBER    X (KM)   Y (KM)   LENGTH OF SIDE (M) 00015000
     1         E1 (G/S)          E2 (G/S)           IDENTIFICATION")    00015010
  932 FORMAT(5X,I4,8X,2(F7.2,2X),5X,F9.2,13X,F8.4,11X,F8.4,11X,2A4)     00015020
  935 FORMAT(1H0,"POINT SOURCE LIST:  ",20A4,10X,"RUN ",I1)             00015030
  940 FORMAT(1H0,"SOURCE NO.   X (KM)     Y (KM)       HT.(M)   DIAM.(M) 00015040
     1VEL.(M/S)   TEMP.(K)     E1(G/S)      E2(G/S)              IDENT  00015050
     2IFICATION")                                                       00015060
  945 FORMAT(3X,I4,3X,2(F8.2,2X),3X,F7.2,2X,F8.3,4X,F7.2,4X,F7.2,5X,    00015070
     1 2(F9.3,4X),15X,2A4)                                              00015080
  946 FORMAT(1H0,"THE SUM OF THE POINT SOURCE EMISSION RATES FOR THIS RU 00015090
     1N IS  ",F9.2,"G/S FOR POLLUTANT 1,  ",F9.2,"G/S FOR POLLUTANT 2") 00015100
  950 FORMAT(1H0,"REGRESSION ANALYSIS:  ",20A4,6X"RUN ",I1)             00015110
  955 FORMAT(1H0,"RECEPTOR NUMBER   X (KM)   Y (KM)",14X,"MEASURED CONCE 00015120
     1NTRATIONS           CALCULATED CONCENTRATIONS"/63X,2("P 1       P 2 00015130
     2       P 3",10X))                                                 00015140
  956 FORMAT(1H0,6X,"***",6X,2(2X,F7.2)," THIS RECEPTOR IS OUTSIDE THE  00015150
     1GRID.")                                                           00015160
  960 FORMAT(7X,I3,6X,2(2X,F7.2),11X,2(F7.2,3X),2(3X,F7.2))             00015170
  962 FORMAT(1H0,"COLUMN  ROW     COORDINATES, KM.",15X,"UNCALIBRATED CON 00015180
     1CENTRATIONS",21X,"CALIBRATED CONCENTRATIONS")                     00015190
  963 FORMAT(1H0,"RUN ",I1,"/ ",20A4," / CONCENTRATIONS IN MICROGRAMS/CU 00015200
     1BIC METER")                                                       00015210
  965 FORMAT(1H0,3X,"NX    NY",9X,"X",9X,"Y",6X,"POLLUTANT 1     POLLUTANT 00015220
     2 2                    POLLUTANT 1     POLLUTANT 2 ")              00015230
  970 FORMAT(" ",2I5,4X,F9.2,2X,F8.2,1X,3F15.6,2X,3F15.6)               00015240
      STOP                                                              00015250
      END                                                               00015260
$SET LINEINFO OWN STACK OPT=1 $                                         00015270
      SUBROUTINE KCALC(DSQ,NSH,FSH,NDIST,KAY,MM,OLIM,IURBAN)            00015280
C                                                                       00015290
C KCALC PRODUCES THE POINT SOURCE K-FACTOR APPROPRIATE TO ANY           00015300
C COMBINATION OF EFFECTIVE STACK HEIGHT AND DOWNWIND DISTANCE           00015310
C FOR EACH STABILITY CLASS.                                             00015320
C                                                                       00015330
      COMMON/FAQMS/WR(16,6,5),KPS(20,19,6),CPS(50,50,2),THETA(6),       00015340
     1XSWC,YSWC,LX,LY,GRID,IRD,IWR,IPU,NAORST(25,25,5),CAORST(25,25,5), 00015350
     2IPT,XSWR,YSWR                                                     00015360
      DIMENSION KAY(6),NSH(5),FSH(6),A(6,3),B(6,3),MM(6),VDINT(19),     00015370
     1OLIM(20)                                                          00015380
      REAL KAY,KPS                                                      00015390
      DATA VDINT/3.333333,5.333333,2.5,2.5,1.,.769231,.625,
     1          .526316,.434783,.37037,.322581,.277778,.243902,.217391,
     2          .192308,.172414,.15625,.140845,.125235/
      DATA A/0.0383,0.1393,0.1120,0.0856,0.0818,0.0545,
     1       0.0002539,0.04936,0.1014,0.2591,0.2527,0.2017,
     2       0.0002539,0.04936,0.1154,0.7368,1.2969,1.5763/
      DATA B/1.2812,0.9467,0.9100,0.8650,0.8155,0.8124,
     1       2.0886,1.1137,0.9260,0.6869,0.6341,0.6020,
     2       2.0886,1.1137,0.9109,0.5642,0.4421,0.3606/
      DIST=SQRT(DSQ)
      DO 200 I=1,20
      IF(DIST.LT.DLIM(21-I)) GO TO 200
      NDIST= 21 - I
      GO TO 300
  200 CONTINUE
      NDIST=1
      DIST=DIST*1000
      IC=1
      IF(DIST.GT.500.) IC=2
      IF(DIST.GT.5000.)IC=3
      DO 210 I=1,6
      IF(I.EQ.6.AND.IURBAN.EQ.1) GO TO 208
      SIGMAZ=A(I,IC)*DIST**B(I,IC)
      GO TO 209
  208 SIGMAZ=A(5,IC)*DIST**B(5,IC)
  209 EXCON=HH(I)*HH(I)/((-2.)*SIGMAZ*SIGMAZ)
      RAY(I)=2031796.351*EXP(EXCON)/(DIST*SIGMAZ)
  210 CONTINUE
      GO TO 410
  300 DO 400 I=1,6
      FDIST=ABS((DIST-DLIM(NDIST))*VDINT(NDIST))
      IN=NSH(I)
      IF(I.EQ.6.AND.IURBAN.EQ.1) GO TO 301
      RAY(I)=(1-FDIST)*((1-FSH(I))*RPS(NDIST,IN,I)+FSH(I)*
     1RPS(NDIST,IN+1,I))+FDIST*((1-FSH(I))*RPS(NDIST+1,IN,I)+
     2FSH(I)*RPS(NDIST+1,IN+1,I))
      GO TO 400
  301 RAY(I)=(1-FDIST)*((1-FSH(I))*RPS(NDIST,IN,5)+FSH(I)*
     1RPS(NDIST,IN+1,5))+FDIST*((1-FSH(I))*RPS(NDIST+1,IN,5)+
     2FSH(I)*RPS(NDIST+1,IN+1,5))
  400 CONTINUE
  410 RETURN
      END
$SET LINEINFO OWN STACK OPT=1 $
      SUBROUTINE SECTOR(XD,YD,IRUN,FREQ)
C
C SECTOR CHOOSES THE ENTRY IN THE JOINT FREQUENCY FUNCTION FOR THE
C CORRECT WIND SECTOR FOR EACH SOURCE-RECEPTOR CONFIGURATION.
C
      COMMON/FAQMS/WR(16,6,5),RPS(20,19,6),CPS(50,50,2),THETA(8),
     1XSWC,YSWC,LX,LY,GRID,IWD,IWR,IPU,NWORST(25,25,5),CWORST(25,25,5),
     2IPT,XSWR,YSWR
      DIMENSION FREQ(6)
      TAN=XD/YD
      DO 400 I=1,7
      IF(TAN.LT.THETA(I).OR.TAN.GT.THETA(I+1)) GO TO 400
      IW=I
      GO TO 450
  400 CONTINUE
      IW=9
  450 IF(TAN.LT.-5.0273.OR.TAN.GT.5.0273) IW=5
      IF(XD.LT.-0.19891*YD) IW=IW+8
      DO 500 I=1,6
  500 FREQ(I)= WR(IW,I,IRUN)
```

```
      RETURN
      END
$SET LINEINFO OWN STACK OPT=1 $
      SUBROUTINE REGAN(IRUN,NPOL,IR,NR,CF,CRR,AN,BN,CORREL,STDERR)
C
C REGAN CALCULATES COEFFICIENTS FOR A LINEAR LEAST-SQUARES FIT TO
C OBSERVED VS. CALCULATED CONCENTRATIONS. CORRELATION COEFFICIENT
C AND STANDARD ERROR ARE ALSO CALCULATED.
C
      COMMON/FRQMS/WN(16,6,5),NPS(20,19,6),CPS(50,50,2),THETA(8),
     1XSWC,YSWC,LX,LY,GRID,IRD,IWR,IPU,NWOBST(25,25,5),CWOBST(25,25,5),
     2IPT,XSWR,YSWR
      DIMENSION CF(2),CRR(2),RN(2),NRP(2)
      DIMENSION F(100,2),R(100,2),SF(2),SR(2),SFF(2),SFR(2),EF(2),ER(2)
      DIMENSION AN(5,2),BN(5,2),CORREL(2),STDERR(2),FM(2),RM(2)
      IF(IR.GT.1) GO TO 160
      DO 140 I=1,NPOL
      NRP(I)=0
      RN(I)=0.
      SF(I)=0.
      SR(I)=0.
      SFF(I)=0.
  140 SFR(I)=0.
  160 IF(IR.EQ.NR) GO TO 200
      DO 190 I=1,NPOL
      IF(CRR(I).LT.1.0E-6) GO TO 190
      NRP(I)=NRP(I) + 1
      RN(I)=NRP(I)
      NT=NRP(I)
      F(NT,I)=CF(I)
      R(NT,I)=CRR(I)
      SF(I)= SF(I) + CF(I)
      SR(I)= SR(I) + CRR(I)
      SFF(I)=SFF(I) + CF(I)*CF(I)
      SFR(I)= SFR(I) + CF(I)*CRR(I)
  190 CONTINUE
      RETURN
  200 DO 250 I=1,NPOL
      AN(IRUN,I)=(SFF(I)*SR(I) - SF(I)*SFR(I))/(RN(I)*SFF(I) - SF(I)
     1*SF(I))
  250 BN(IRUN,I)=(RN(I)*SFR(I) - SF(I)*SR(I))/(RN(I)*SFF(I) - SF(I)
     1*SF(I))
      DO 270 I=1,NPOL
      FM(I)=0.
  270 RM(I)=0.
      NR=NR-1
      DO 310 J=1,NPOL
      DO 300 I=1,NR
C
C FM AND RM WILL BE USED TO REPRESENT MEAN F AND R.
C
      FM(J)= FM(J) + F(I,J)
  300 RM(J)= RM(J) + R(I,J)
      FM(J)=FM(J)/RN(J)
  310 RM(J)=RM(J)/RN(J)
C
C EF AND ER WILL BE USED AS ERROR SUMS
C
      DO 350 I=1,NPOL
      EF(I)=0.
  350 ER(I)=0.
      DO 550 J=1,NPOL
      DO 500 I=1,NR
      IF(NRP(J).LT.I) GO TO 525
```

Reproduced from
best available copy.

```
      EF(J)= EF(J) + (R(I,J) - RM(J))**2
  500 ER(J)= ER(J) + ((AN(IRUN,J)+BN(IRUN,J)*F(I,J)) - RM(J))**2
      IF(EF(J).GT.1.0E-5) GO TO 525
      WRITE (IWR,624)
  624 FORMAT (1H1,"****ERROR****ALL INPUTS FOR MEASURED VALUES CAN NOT
     1BE THE SAME VALUE.")
      STOP
  525 CORREL(J)= SQRT(ER(J)/EF(J))
  550 IF(CORREL(J).NE.1) STDERR(J)=SQRT((EF(J)/NR)*(1. -
     1CORREL(J)*CORREL(J)))
      DO 700 I=1,NPOL
      WRITE(IWR,625)I,AN(IRUN,I),BN(IRUN,I),CORREL(I),STDERR(I)
  625 FORMAT(1H0,"POLLUTANT ",I1," CALIBRATION CTS. AN = ",E12.5,",
     1BN = ",E12.5,", CORRELATION COEFFICIENT = ",F10.7,", STD. ERR. =",
     2E12.5)
  700 CONTINUE
      NR=NR+1
      RETURN
      END
$SET LINEINFO OWN STACK OPT=1 $
      SUBROUTINE ARRAY(IRUN,NPOL,INPOL,AN,BN,TT,TN,IURBAN,NARRAY,POLNAM,
     1CALNAM)
C
C SUBROUTINE ARRAY CREATES ARRAY MAPS OF THE CONCENTRATIONS IN THE
C RECEPTOR GRID AND PRINTS THEM AT THE END OF EACH SCENARIO.
C UNCALIBRATED AND CALIBRATED CONCENTRATIONS OF EACH POLLUTANT
C APPEAR ON SEPARATE MAPS OF UP TO FOUR SECTIONS (PAGES) EACH.
C
      COMMON/FARMS/WR(16,6,5),NPS(25,19,6),CPS(50,50,2),THETA(8),
     1XSWC,YSWC,LX,LY,GRID,IRD,IWR,IPU,WWORST(25,25,5),CWORST(25,25,5),
     2IPT,XSWR,YSWR
      DIMENSION AN(5,2),BN(5,2),TT(20),L(2),X(50),CC(50),TN(5,20),
     1POLNAM(3,2),CALNAM(5,7,2)
      INTEGER CC
      NLX=1
      NLY=1
      IF(LX.GT.25) NLX=2
      IF(LY.GT.25)NLY=2
      ISECT=0
      NSECT=NLX*NLY
      DO 700 JLX=1,NLX
      MX2= JLX*25
      IF(MX2.GT.LX) MX2=LX
      MX1=1
      IF(JLX.EQ.2) MX1=26
      DO 125 I=MX1,MX2
      XI=I
  125 X(I)= XSWR + (XI-0.5)*GRID
      DO 600 JLY=1,NLY
      ISECT=ISECT+1
      IF(JLY.EQ.1) GO TO 150
      MY1=25
      MY2=LY
      GO TO 175
  150 MY1=1
      MY2=25
      IF(LY.LT.25) MY2=LY
  175 DO 500 N=1,NPOL
      IF(NARRAY.EQ.3) GO TO 320
      M=N
      IF(INPOL.EQ.2) M=2
      IF(IURBAN.EQ.0) WRITE(IWR,905)ISECT,NSECT,IRUN,M,(POLNAM(I,M),
     1I=1,3)
      IF(IURBAN.EQ.1) WRITE(IWR,906)ISECT,NSECT,IRUN,M,(POLNAM(I,M),
     1I=1,3)
      WRITE(IWR,910)TT
      WRITE(IWR,911)(TN(IRUN,K),K=1,20)
      WRITE(IWR,915)(X(I),I=MX1,MX2,2)
      DO 300 J=MY1,MY2
      IY=MY2+MY1-J
      Y=IY
      Y=YSWR + (Y-0.5)*GRID
      DO 230 I=MX1,MX2
  230 CC(I)=CPS(I,IY,M) + 0.5
      WRITE(IWR,920)Y,(CC(I),I=MX1,MX2)
  300 WRITE(IWR,925)Y
      WRITE(IWR,915)(X(I),I=MX1,MX2,2)
      IF(NARWAY.EQ.2) GO TO 600
  320 IF(IURBAN.EQ.0) WRITE(IWR,907)ISECT,ASECT,IRUN,M,(POLNAM(I,M),
     1I=1,3),(CALNAM(IRUN,I,M),I=1,7)
      IF(IURBAN.EQ.1) WRITE(IWR,908)ISECT,ASECT,IRUN,M,(POLNAM(I,M),
     1I=1,3),(CALNAM(IRUN,I,M),I=1,7)
      WRITE(IWR,910)TT
      WRITE(IWR,911)(TN(IRUN,K),K=1,20)
      WRITE(IWR,915)(X(I),I=MX1,MX2,2)
      DO 400 J=MY1,MY2
      IY=MY2+MY1-J
      Y=IY
      Y=YSWR + (Y-0.5)*GRID
      IF(INPOL.EQ.2) AN(IRUN,1) = AN(IRUN,2)
      IF(INPOL.EQ.2) BN(IRUN,1) = BN(IRUN,2)
      DO 330 I=MX1,MX2
  330 CC(I)= AN(IRUN,M) + BN(IRUN,M)*CPS(I,IY,M) + 0.5
      WRITE(IWR,920)Y,(CC(I),I=MX1,MX2)
  400 WRITE(IWR,925)Y
  500 WRITE(IWR,915)(X(I),I=MX1,MX2,2)
  600 CONTINUE
  700 CONTINUE
      RETURN
  905 FORMAT(1H1,/,3X,"SECTION ",I1," OF ",I1,3X,"RUN NUMBER ",I1,", POL
     1LUTANT ",I1," (",3A6,") ,UNCALIBRATED CONCENTRATIONS IN UG/M3",
     221X,"TCM-2  RURAL")
  906 FORMAT(1H1,/,3X,"SECTION ",I1," OF ",I1,3X,"RUN NUMBER ",I1,", POL
     1LUTANT ",I1," (",3A6,") ,UNCALIBRATED CONCENTRATIONS IN UG/M3",
     221X,"TCM-2  URBAN")
  907 FORMAT(1H1,/,3X,"SECTION ",I1," OF ",I1,3X,"RUN NUMBER ",I1,", POL
     1LUTANT ",I1," (",3A6,") ,CALIBRATED CONCENTRATIONS (",7A6,
     2") TCM-2  RURAL")
  908 FORMAT(1H1,/,3X,"SECTION ",I1," OF ",I1,3X,"RUN NUMBER ",I1,", POL
     1LUTANT ",I1," (",3A6,") ,CALIBRATED CONCENTRATIONS (",7A6,
     2") TCM-2  URBAN")
  910 FORMAT(27X,20A6)
  911 FORMAT(1H0,27X,"METEOROLOGY:  ",20A6,//)
  915 FORMAT(1H0,16X,13F8.2)
  920 FORMAT(1H0,5X,F7.2,4X,25I4)
  925 FORMAT(1H+,120X,F7.2)
      END
$SET LINEINFO OWN STACK CPI=1 $
      SUBROUTINE WORST(I,J,CHI)
C SUBROUTINE WORST DETERMINES THE FIVE POINT SOURCES CONTRIBUTING THE
C MOST TO THE TOTAL CONCENTRATION AT EACH RECEPTOR.
C CWORST IS USED TO STORE SOURCE CONTRIBUTIONS
C NWORST IS USED TO STORE SOURCE IDENTIFICATIONS
      COMMON/PARMS/WR(16,6,5),KPS(20,19,6),CPS(50,50,2),THETA(9),
     1XSWC,YSWC,LX,LY,GRID,IWD,IWR,IPU,NWORST(25,25,5),CWORST(25,25,5),
     2IPT,XSWR,YSWR
      IF(CHI.LE.CWORST(I,J,5)) RETURN
      IF(CHI.GT.CWORST(I,J,4)) GO TO 205
      CWORST(I,J,5)=CHI
      NWORST(I,J,5)=IPT
      RETURN
  205 IF(CHI.GT.CWORST(I,J,3)) GO TO 210
      NW=1
      GO TO 225
  210 IF(CHI.GT.CWORST(I,J,2)) GO TO 215
      NW=2
      GO TO 225
  215 IF(CHI.GT.CWORST(I,J,1)) GO TO 220
      NW=3
      GO TO 225
  220 NW=4
  225 DO 250 IW=1,NW
      CWORST(I,J,6-IW)= CWORST(I,J,5-IW)
  250 NWORST(I,J,6-IW)= NWORST(I,J,5-IW)
      CWORST(I,J,5-NW)= CHI
      NWORST(I,J,5-NW)= IPT
      RETURN
      END
$SET LINEINFO OWN STACK OPT=1 $
      SUBROUTINE WOROUT(TT,IRUN,TN)
C
C  SUBROUTINE WOROUT PRINTS A CULPABILITY LIST OF THE IDENTIFICATIONS
C  AND CONTRIBUTIONS OF THE FIVE POINT SOURCES CONTRIBUTING THE MOST
C  TO THE TOTAL CONCENTRATION AT EACH RECEPTOR, USING DATA COMPILED
C  BY SUBROUTINE WORST.
C
      COMMON/FACMS/ WR(16,6,5),RPS(20,19,6),CPS(50,50,2),THETA(8),
     1XSWC,YSWC,LX,LY,GRID,IRD,IWR,IPU,NWORST(25,25,5),CWORST(25,25,5),
     2IPT,XSWR,YSWR
      DIMENSION TT(20),TN(5,20)
      DO 400 I=1,LX
      WRITE(IWR,905)
      WRITE(IWR,910)TT,IRUN
      WRITE(IWR,911)TN
      WRITE(IWR,920)
      XI=I
      X= XSWR + (XI-0.5)*GRID
      DO 400 J=1,LY
      IF(CPS(I,J,1).LT.1.0E-5) GO TO 303
      DO 300 L=1,5
  300 CWORST(I,J,L)= CWORST(I,J,L)*100./CPS(I,J,1)
  303 YJ=J
      Y= YSWR + (YJ-0.5)*GRID
      WRITE(IWR,925)I,J,X,Y,NWORST(I,J,1),CWORST(I,J,1),NWORST(I,J,2),
     1 CWORST(I,J,2),NWORST(I,J,3),CWORST(I,J,3),NWORST(I,J,4),
     2 CWORST(I,J,4),NWORST(I,J,5),CWORST(I,J,5),CPS(I,J,1)
  400 CONTINUE
  905 FORMAT(1H1,"TEXAS CLIMATOLOGICAL MODEL CONTROL STRATEGY DATA: LIST
     1 OF THE FIVE POINT SOURCES PRODUCING HIGHEST CONCENTRATIONS AT EAC
     2H RECEPTOR")
  910 FORMAT(1H0,20A4,37X,"RUN NUMBER ",I1/)
  911 FORMAT(1H0,27X,"METEOROLOGY FOR:   ",20A4,//)
  920 FORMAT(1H0,13X,"RECEPTOR COORDINATES       POINT SOURCE SEQUENCE NU
     1MBER AND PERCENT OF TOTAL CONCENTRATION AT RECEPTOR     TOTAL FOR"
     2/" COLUMN ROW      X (KM)      Y (KM)       NO.  HIGHEST    NO. 2ND
     3HIGH    NO. 3RD HIGH    NO. 4TH HIGH    NO. 5TH HIGH      RECEPTOR"
     4)
  925 FORMAT(1H0,1X,I2,3X,I2,5X,2(F8.2,3X),5(3X,I4,"=",F8.2),5X,F8.2)
      RETURN
      END
$SET LINEINFO OWN STACK OPT=1 $
      SUBROUTINE RISE(IRISE,VUC,IBODY,EFF,XS,ESH,ESHW,V,D,DIST,H,TA,
     1IRUN,IS,IURBAN)
C
```

```
C SUBROUTINE RISE CALCULATES PLUME RISE VIA ONE OF SIX EQUATIONS
C (BRIGGS,1969).  IF IRISE=1, DISTANCE DEPENDENT EFFECTIVE SOURCE
C HEIGHT (ESHH(IS)) IS RETURNED.  IF IRISE=2, MAXIMUM EFFECTIVE SOURCE
C HEIGHT (ESH(IS)) IS RETURNED.  RISE IS CALLED ONCE PER SOURCE PER
C SCENARIO WITH IRISE=2.  IT IS CALLED WITH IRISE=1 WHENEVER THE
C DOWNWIND DISTANCE (DIST) IS LESS THAN THE DISTANCE TO MAXIMUM
C PLUME RISE (PEAK).
C
      COMMON/FACMS/WR(16,6,5),KPS(20,19,6),CPS(50,50,2),THETA(8),XSWC,
     1YSWC,LX,LY,GRID,IRD,IWR,IPU,VWORST(25,25,5),CWORST(25,25,5),IPT,
     2XSWR,YSWR
      DIMENSION CTB(6),CTMU(6),DELTAH(6),ESH(6),ESHH(6),VUE(6),TA(5),
     1IBUOY(6)
      IF(IRISE.EQ.1) GO TO 300
      IF(IBUOY(IS).EQ.0) GO TO 205
      IF(EFF.GE.55.) GO TO 150
C
C XS,CTB, AND CTMU ARE INDEPENDENT OF DISTANCE, AND ARE THEREFORE
C CALCULATTED ONCE PER SOURCE PER SCENARIO (WHEN IRISE=2).
C
      XS=49.*EFF**0.625
      GO TO 160
  150 XS=119.*EFF**0.4
  160 CTB(IS)=1.6*VUE(IS)*EFF**0.33333
      IF(IS.EQ.6.AND.IURBAN.EQ.0) GO TO 170
C
C PEAK PLUME RISE: BUOYANCY-DOMINATED PLUME,UNSTABLE AIR (A-D).
C
      DELTAH(IS)=CTB(IS)*XS**0.666667
      GO TO 250
C
C PEAK PLUME RISE: BUOYANCY-DOMINATED PLUME, STABLE AIR (E-F).
C
  170 DELTAH(IS)=2.6*(EFF*VUE(IS)*5.09989*TA(IRUN))**0.333333
      GO TO 250
  205 IF(IS.EQ.6.AND.IURBAN.EQ.0) GO TO 230
      CTMU(IS)=1.89*(V*V*D*VUE(IS)/(V+3./VUE(IS)))**0.666667
C
C PEAK PLUME RISE: MOMENTUM-DOMINATED PLUME, UNSTABLE AIR (A-D).
C
      DELTAH(IS)=3.*V*D*VUE(IS)
      GO TO 250
C
C PEAK PLUME RISE: MOMENTUM-DOMINATED PLUME, STABLE AIR (E).
C
  230 DELTAH(IS)=1.5*(0.5*V*D)**0.666667*VUE(IS)**0.33333*
     1(5.09989*TA(IRUN))**0.166667
  250 ESH(IS)=H+DELTAH(IS)
      RETURN
  300 IF(IBUOY(IS).EQ.0) GO TO 500
C
C DISTANCE-DEPENDENT PLUME RISE: BUOYANCY-DOMINATED PLUME.
C ANY STABILITY (A-E).
C
      ESHH(IS)=CTB(IS)*(DIST*1000.)**0.666667+H
      IF(ESHH(IS).GT.ESH(IS)) ESHH(IS)=ESH(IS)
      RETURN
C
C DISTANCE-DEPENDENT PLUME RISE: MOMENTUM-DOMINATED PLUME.
C UNSTABLE AIR (A-D).
C
  500 ESHH(IS)=CTMU(IS)*(DIST*1000.)**0.33333+H
      IF(ESHH(IS).GT.ESH(IS)) ESHH(IS)=ESH(IS)
      RETURN
```

Reproduced from
best available copy.

```
C
C THERE IS NO DISTANCE-DEPENDENT PLUME RISE GIVEN FOR A
C MOMENTUM-DOMINATED PLUME IN STABLE AIR.  DISTANCE TO MAXIMUM PLUME
C RISE FOR THIS SITUATION IS SET EQUAL TO ZERO IN THE MAIN PROGRAM.
C SO THE MAXIMUM HEIGHT, ESH(I), IS USED AT ALL DISTANCES.
C
      END
$SET LINEINFO OWN STACK OPI=1 &
      SUBROUTINE MAXOUT(IRUN,NRUNS,NPOL,INPOL,AN,BN,IURBAN,TT,IN,
     1CALNAM,POLNAM)
C
C SUBROUTINE MAXOUT DETERMINES THE MAXIMUM CONCENTRATION FOR EACH
C SCENARIO AND PRINTS THIS DATA ON A SEPARATE SHEET AT THE END OF
C THE RUN.
C
      COMMON/FAGN5/WR(16,6,5),RPS(20,19,6),CPS(50,50,2),THETA(8),XSWC,
     1YSWC,LX,LY,GRID,IRD,IWR,IPU,WWORST(25,25,5),CWORST(25,25,5),IPT,
     2XSWR,YSWR
      DIMENSION ZMAX(5,2),XMAX(5,2),YMAX(5,2),AN(5,2),BN(5,2),TT(20),
     1IN(5,20),ZMC(5,2),POLNAM(3,2),CALNAM(5,7,2)
      REAL KAY,RPS
      DO 100 K=1,NPOL
      Z=0.
      DO 50 I=1,LX
      DO 50 J=1,LY
      IF (CPS(I,J,K).LT.Z) GO TO 50
      Z=CPS(I,J,K)
      ZX=I
      ZY=J
   50 CONTINUE
      ZMAX(IRUN,K)=Z
      XMAX(IRUN,K)=XSWC + (ZX-1.)*GRID
      YMAX(IRUN,K)=YSWC + (ZY-1.)*GRID
      ZMC(IRUN,K)=AN(IRUN,K) + BN(IRUN,K)*ZMAX(IRUN,K)
  100 CONTINUE
      IF (IRUN.EQ.NRUNS) GO TO 200
      RETURN
  200 IF(IURBAN.EQ.0) WRITE(IWR,900)
      IF(IURBAN.EQ.1) WRITE(IWR,901)
      WRITE(IWR,902)TT
      DO 300 IR=1,NRUNS
  300 WRITE(IWR,905)IR,(IN(IR,K),K=1,20)
      WRITE(IWR,905)
      DO 350 IR=1,NRUNS
  350 WRITE(IWR,907)IR,AN(IR,1),BN(IR,1),(CALNAM(IR,K,1),K=1,7),
     1AN(IR,2),BN(IR,2),(CALNAM(IR,K,2),K=1,7)
      WRITE(IWR,905)
      WRITE(IWR,903)(POLNAM(I,1),I=1,3),(POLNAM(I,2),I=1,3)
      DO 400 IR=1,NRUNS
      IF(INPOL.EQ.2) WRITE(IWR,910)IR,XMAX(IR,1),YMAX(IR,1),
     1ZMAX(IR,1),ZMC(IR,1)
      IF(INPOL.EQ.2) GO TO 400
      WRITE(IWR,915)IR,(XMAX(IR,K),YMAX(IR,K),ZMAX(IR,K),
     1ZMC(IR,K),K=1,NPOL)
  400 CONTINUE
      RETURN
  900 FORMAT(1H1,24X,"T E X A S   C L I M A T O L O G I C A L   M O D E
     1L  -  V E R S I O N - 2  (R U R A L)",//)
  901 FORMAT(1H1,24X,"T E X A S   C L I M A T O L O G I C A L   M O D E
     1L  -  V E R S I O N - 2  (U R B A N)",//)
  902 FORMAT(25X,"HIGHEST PREDICTED CONCENTRATIONS FOR EACH POLLUTANT FO
     1R EACH SCENARIO",//,27X,20A4,//,129("-"),//,3X,"RUN",9X,"METEOROLO
     2GY",/,2X,"NUMBER",/)
  903 FORMAT(//,129("-"),//,16X,"RECEPTOR COORDINATES",5X,"POLLUTANT 1 (
     1",3A4,")",5X,"RECEPTOR COORDINATES",6X,"POLLUTANT 2 (",3A4,")",
     2/,"     RUN",32X,"UNCALIBRATED     CALIBRATED",31X,
     3"UNCALIBRATED     CALIBRATED",/,"   NUMBER",9X,"X (KM)     Y (KM)"
     4,8X,"CONCENTRATION  CONCENTRATION",5X,"X (KM)     Y (KM)"
     5,8X,"CONCENTRATION  CONCENTRATION",/)
 903 FORMAT(3X,I2,9X,20A4,/)
 905 FORMAT(//,120("-"),//," UNCALIBRATED CONCENTRATIONS IN MICROGRAMS
     1 PER CUBIC METER",///,3X,"RUN",7X,"POLLUTANT 1 CALIBRATION",35X,
     2"POLLUTANT 2 CALIBRATION",/,2X,"NUMBER",9X,"A 1",9X,"B 1",43X,
     3"A 2",9X,"B 2",/)
 907 FORMAT(3X,I2,5X,2(F10.4,2X,F10.6,5X,7A4,3X),/)
 906 FORMAT(" CALIBRATED CONC = A(I) + B(I)*CALCULATED CONC")
 910 FORMAT(5X,I2,64X,2(F5.3,2X),6X,2(F10.4,5X),/)
 915 FORMAT(5X,I2, 6X,2(F8.3,2X),5X,2(F10.4,5X),1X,2(F8.3,2X),6X,
     12(F10.4,5X),/)
      END
```